THURSDAY, JUNE 22, 1876

WALLACE'S GEOGRAPHICAL DISTRIBUTION OF ANIMALS

The Geographical Distribution of Animals, with a Study of the Living and Extinct Faunas, as Elucidating the Past Changes of the Earth's Surface. By Alfred Russel Wallace. Two Vols. 8vo. (London: Macmillan and Co., 1876.)

THE question of the number and boundaries of the primary zoological regions of the Globe has recently been discussed by Prof. Newton in his article on "Birds," in the new edition of the "Encyclopædia Britannica." After remarks on the failure of previous writers to solve this problem in a satisfactory manner, Prof. Newton comes to the conclusion that the outlines of distribution laid down in 1857 by Mr. Sclater, although founded only upon the study of the erratic class of birds, have "not merely in the main, but to a very great extent in detail, met with the approval of nearly all those zoologists who have since studied the subject in its bearing upon the particular classes in the knowledge of which they themselves stand pre-eminent." In point of fact, Mr. Wallace himself was one of the first naturalists to accept Mr. Sclater's views on this subject. Writing from the remote island of Batchian, in the Indian Archipelago, in March 1859, after perusing Mr. Sclater's well-known memoir on the Geographical Distribution of Birds,[1] Mr. Wallace says, in a letter to Mr. Sclater published in the first volume of the *Ibis*,[2] "With your division of the earth into six grand zoological provinces I perfectly agree, and I believe they will be confirmed by every other department of zoology as well as by botany." In the two excellent volumes now before us, in which are embodied the results of several years continuous labour upon this and kindred branches of the same subject, it will be seen that Mr. Wallace has not altered his opinion. The six great primary zoological regions of the globe proposed by Mr. Sclater in 1857 are fully adopted, and form the basis of Mr. Wallace's whole treatment of the subject. But one slight change even in their nomenclature is made—that of substituting "Oriental" as the name of the Region embracing South Asia and the adjacent islands for Mr. Sclater's term "Indian." In fact, after discussing the general principles and phenomena of distribution and what little we as yet know concerning the distribution of extinct animals, the main portion of Mr. Wallace's volumes is occupied by an elaborate sermon on Mr. Sclater's text, and on its application to other classes of animals. The various phenomena of life exhibited in the Palæarctic, Ethiopian, Oriental, Australian, Neotropical, and Nearctic regions are treated of in succession, and their similarities and their differences are discussed. To this is added a sketch of the geographical distribution of the principal families of terrestrial animals arranged systematically, which forms the fourth part of this important work. Of this last portion, which is, in fact, a book of reference containing an account of the distribution of all the families, and of most of the genera of the higher animals arranged in systematic order, we propose to speak in a subsequent article. For the present we will confine our attention to the first three parts of Mr. Wallace's work.

The introductory chapter, with which the first volume of the "Geographical Distribution of Animals" is commenced, although it states the object of the work plainly enough to the mind of the scientific reader, seems a little too brief and concise to explain the nature of the problem under discussion to the general public. It must be borne in mind that the very idea of the existence of any regular laws of distribution is a novelty to most people—even, we regret to say, to many who call themselves naturalists. It is to be regretted, therefore, we think, that Mr. Wallace has not devoted a few more pages to the general explanation of the subject of which he treats, to the pointing out of the many subordinate problems which it involves, and in particular to the further explanation and definition of such technical terms as "*habitat*," "stations," "range," and "representative species," which confront us in some of the very first pages of his work.

In his second chapter Mr. Wallace discusses the means by which animals are dispersed, and devotes a good deal of space to the question of migration. Now, migration is, no doubt a very important phenomenon, but whether it has much to do with the general theory of distribution appears to be rather doubtful. It occurs only in one or two groups of animals; and, as Mr. Wallace himself observes, "we must, except in special cases, consider the true range of a species to comprise all the area which it occupies regularly for any part of the year." Migration, therefore, primarily affects the distribution of a species within its own specific area, and only has to do with the general question of distribution so far as it may increase the tendency of a species to vary its range. With Mr. Wallace's views on the subject of dispersal generally we cordially agree. There can be no question that, in the "glacial epoch" and in the more recent geological changes which have taken place on the earth's surface, the key of the present complicated phenomena of distribution should be sought, although many of them have had a much earlier origin. "Almost every mile of land-surface has been again and again depressed beneath the ocean; most of the great mountain chains have either originated or greatly increased in height during the Tertiary period; marvellous alterations of climate and vegetation have taken place over half the land-surface of the earth; and all these vast changes have influenced a globe so cut up by seas and oceans, by deserts and snow-clad mountains, that in many of its more isolated land-masses, ancient forms of life have been preserved, which, in the more extensive and more varied continents have long given way to higher types."

Mr. Wallace now proceeds to enter upon the grand question of Zoological Regions, entirely ignored, as he truly says, by the older school of naturalists. To them, provided they got the object, it little mattered whence it came. "The Brazils," the "East Indies," or the "South-sea Islands," was considered *ample* information as to the locality of any specimen, even if it were thought necessary to give such information at all. How could such men appreciate the idea of Zoological Regions? They

[1] See "Journal of the Proceedings of the Linnean Society," Zoology, ii. p. 130.

[2] Letter from Mr. Wallace concerning the Geographical Distribution of Birds. (*Ibis*, 1859, pp. 449)

had a sort of vague notion that certain forms were peculiar to hot climates, and that certain others were only found in cold countries, but that was about all they knew or cared to know. Of the necessity of precise knowledge on the subject of locality they were absolutely incredulous.

"To the modern naturalist, on the other and," as Mr. Wallace most truly observes, "the native country (or 'habitat' as it is technically termed) of an animal, or a group of animals, is a matter of the first importance; and as regards the general history of life upon the globe, may be considered to be one of its essential characters. The structure, affinities, and habits of a species, now form only a part of its natural history.

"We require also to know its exact range at the present day and in prehistoric times, and to have some

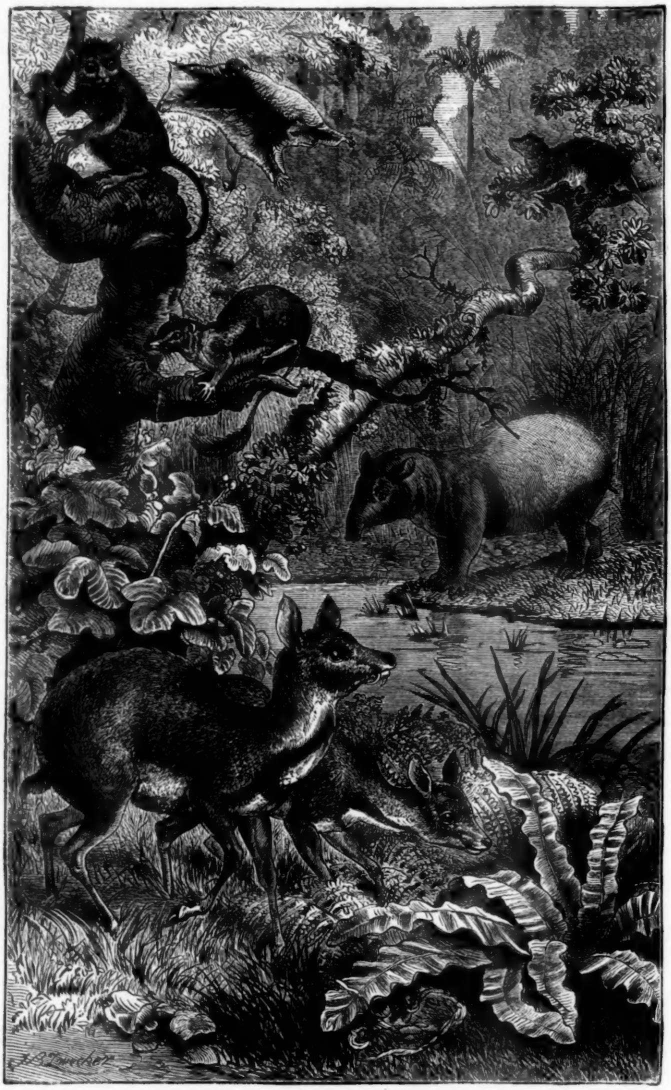


Fig. 1.—Forest in Borneo.

knowledge of its geological age, the place of its earliest appearance on the globe, and of the various extinct forms most nearly allied to it. To those who accept the theory of development as worked out by Mr. Darwin, and the views as to the general permanence and immense antiquity of the great continents and oceans so ably developed by Sir Charles Lyell, it ceases to be a matter of surprise that the tropics of Africa, Asia, and America should differ in their productions, but rather that they should have anything in common. Their similarity, not their diversity, is the fact that most frequently puzzles us."

Yet, in spite of the increased attention paid to locality by Swainson, Waterhouse, Strickland and all the more

highly educated class of naturalists within the last fifty years, it was not until 1857 that the plan of determining the great zoological regions of the earth's surface not from *à priori* reasons of heat and cold, nor from the ordinary views of geographers, but by the minute study of the actual ranges of the more important and best known groups of animals was suggested. Mr. Sclater's Regions, then originally established from consideration of the ranges of the principal families and genera of birds, were quickly applied by Dr. Günther to reptiles and batrachians, and subsequently by Mr. Sclater himself to mammals. Working from the same stand-point, various naturalists have of late years tried to improve upon them, amongst others Mr. Blanford, Mr. Blyth, and

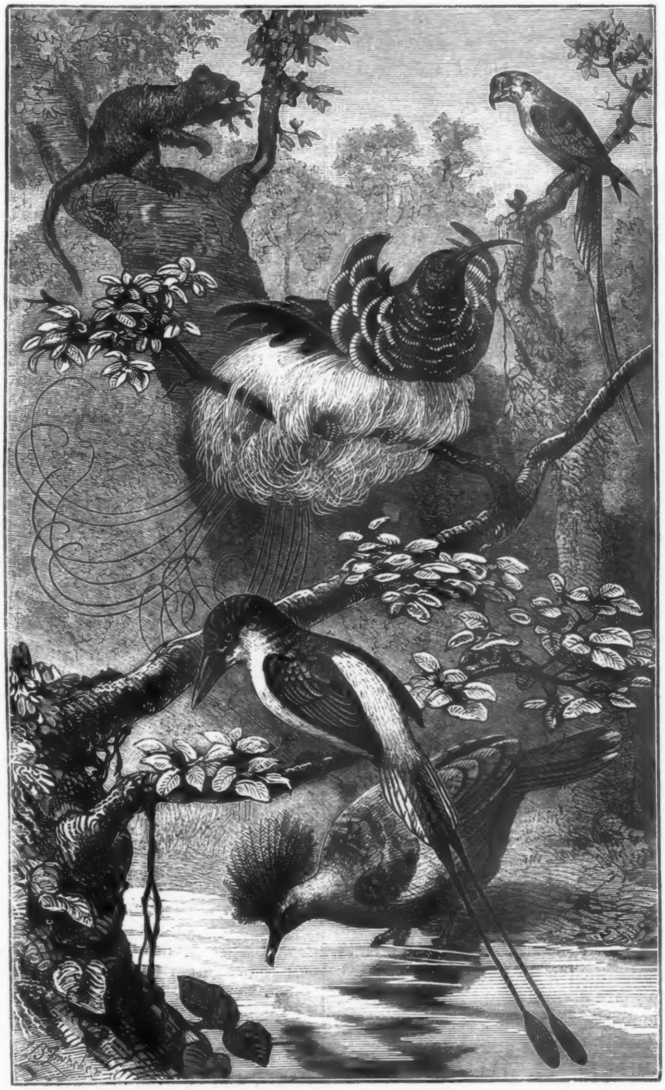


FIG. 2.—Scene in New Guinea.

Prof. Huxley. Mr. Wallace will have none of these—nay, so convinced is he of the correctness of Mr. Sclater's original "happy thoughts"—that he will not even listen to the inventor's own emendations of his original regions. "So that we do not violate any clear affinities"—he observes, "or produce any glaring irregularities, it is a positive, and by no means an unimportant advantage to have our named regions approximately equal in size, and with easily defined and easily remembered boundaries."

He therefore condemns "all elaborate definitions of inter-penetrating frontiers" and "regions extending over three-fourths of the land-surface of the globe" as "most inconvenient—even if there were not such differences of opinion about them." He admits that the "most radical

zoological division of the earth" is made by "separating the Australian regions from the rest," and that the best natural division of the remainder is effected by cutting off the Neotropical region. We should then have three primary zoological regions, which first Prof. Huxley, and afterwards Mr. Sclater, in his oral lectures on geographical distribution seemed to consider as of nearly equal importance. On this Mr. Wallace remarks that "in isolation and speciality, determined by what they want, as well as by what they possess, the Australian and Neotropical regions are undoubtedly each comparable with the rest of the earth. But in richness and variety of forms they are both very much inferior, and are much more nearly comparable with the separate regions which compose it." After discussing this subject at some length, and disposing shortly of Mr. Allen's system of "circumpolar zones," Mr. Wallace comes to the conclusion that a consideration of all the facts zoological and palæontological, indicates that the great northern division, or *Arctogæa*, is as much more important than either Australia or South America, as its four component parts are less important. He therefore reverts to the six original regions proposed by Mr. Sclater in 1857, as the most workable, and most conveniently adapted for the study of zoological distribution.

Thus much having been settled, Mr. Wallace proceeds to point out the limits of the six great regions, and to indicate the sub-regions into which they may be best divided. As regards the latter part of this task there is much difficulty. It must be confessed that the sub-regions in many cases are as yet only approximately determined, and that those adopted by Mr. Wallace are in several instances open to serious question. For example, "the great central mass of South America, from Venezuela to Paraguay" is constituted in the present work as a single division of the Neotropical region under the name of the "Brazilian Sub-region." But there can be no doubt that within this area there are two, if not three, distinct sub-regions which deserve recognition. The fauna of south-eastern Brazil, so admirably investigated by Prince Max. of Neuweid, Burmeister, Reinhardt, and other well-known naturalists, is very distinct from that of the great Amazonian valley, and the adjacent flats of Guiana and the Orinoco. Many genera are peculiar to each of them, and a whole host of representative species perform similar functions within the respective areas. Herr von Pelzeln's divisions of the Neotropical region, and those employed by Messrs. Sclater and Salvin in their papers published in the Zoological Society's *Proceedings*, are much more natural than those suggested by Mr. Wallace. We fear that in spite of what he says on the subject our author has rather allowed a hankering after uniformity to lead him astray and to induce him to restrict his sub-regions to four in each case.

The chapter on Classification which next follows, and concludes the first portion of the work, contains some very apposite remarks. A natural classification of animals is, as Mr. Wallace observes, of first-rate importance in discussing matters of distribution. But, except in the case of a few groups, we have by no means yet attained to a natural classification of animals, and even as regards these we are, in the opinion of many naturalists, still very far from it. It is only therefore some few of the classes of animals that are sufficiently known to be useful for the study of distribution. As such Mr. Wallace selects the Vertebrata, the butterflies, and six families of Coleoptera amongst the insects, and the terrestrial and fresh-water land-shells amongst the Mollusca. Of these better-known groups he gives us tables of the arrangement which he proposes to adopt for the illustration of his remarks on their geographical distribution.

(*To be continued.*)

OUR BOOK SHELF

Notes on Collecting and Preserving Natural History Objects. By J. E. Taylor, E. F. Elwin, Thos. Southwell, Dr. Knaggs, E. C. Rye, J. B. Bridgman, Prof. Ralph Tate, Jas. Britten, Prof. Buckman, Dr. Braithwaite, Worthington G. Smith, Rev. Jas. Crombie, W. H. Grattann. Edited by J. E. Taylor, Ph.D., F.L.S., F.G.S., &c. (London: Hardwicke and Bogue, 1876.)

THIS is a republication of a series of papers from *Science Gossip*; and the names of the respective authors is a sufficient guarantee for the value and accuracy of the information it affords. It is a very useful book to put into the hands of young persons with some taste for natural history but quite ignorant of how to collect and what to observe; since it devotes as much space to the latter branch as to the former, and is thus a more instructive work than its title indicates. The subjects discussed are—geological specimens, bones, birds' eggs, lepidoptera, beetles, hymenoptera, land and fresh-water shells, flowering plants, grasses, mosses, fungi, lichens, and seaweeds. It is a pity that a few other essays were not obtained—on birds, mammals, reptiles, fresh-water fishes, crustacea, spiders, and sea-shells—so as to make the book somewhat more complete as regards "Natural History Objects;" but so far as it goes it is an excellent little work, and is perhaps better adapted to encourage an incipient taste for the study of nature than many more pretentious volumes. The chapters on birds' eggs, butterflies, and beetles, are especially full and interesting; while those on bones and fungi are valuable, as likely to incite the reader to take up the study of these somewhat neglected objects.

A. R. W.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

The Harris Cubit of Karnak

As the measures of this cubit hitherto published are more or less incomplete, the following series may be worth attention.

For permission to examine this relic, I am indebted to Dr. Birch, under whose care it is placed in the British Museum; and who, with his usual courtesy, gave every facility for its measurement.

The readings were taken by laying this wooden cubit on a brass standard scale, divided to tenths of an inch and to millimetres, with its divided face at right angles to that of the scale. Two observers then read the values of the divisions in both inches and metres, giving four readings in all, at about 66° F. The standard scale has since been kindly verified by Mr. H. W. Chisholm, Warden of the Standards, and its error is not of such an amount as to affect the figures here given; it is now in the Loan Collection of Scientific Apparatus (200), the sole representative at South Kensington of Kater's standards.

The readings were mapped on divided paper, and the mean result for each line carefully estimated, with its probable error, by the two observers: and though the following readings of the divisions are of course far from the limit of attainable accuracy, yet as their errors are but a small fraction of those of the gradua-

tions of the cubit, farther accuracy would be nearly useless, especially in view of the width and deficient symmetry of the dividing lines.

The zero point of the series is adjusted so as to fit the normal scale of equal spaces deduced from it, with equal errors + and –, on the series of palms.

	British Inches. Cubit Divisions.	British Inches. Normal Scale.
End of rod	—·026	·000
Palms	2·952	2·956
	5·911	5·913
	8·873	8·869
	11·820	11·826
	14·779	14·785
	17·735	17·739
	20·702	20·695
	23·665	23·652
	26·605	26·608
	29·582	29·565
	32·516	32·521
	35·481	35·477
Digit	36·195	36·217
Condyle	36·922	36·956
Digit	37·694	37·695
Palm	38·417	38·434
Condyle	39·910	39·912
End of rod	41·402	41·390

The average probable error of these determinations of each line (omitting the ends) is ·0008 inch, so that it may be called 1 on the last place of figures here given.

The total length of the rod is 41·428 with a probable error of ± ·0025. Sir Gardner Wilkinson (and Queipo from him?) states it as 41·30; John Taylor, 41·46; and Col. Sir Henry James, 41·398. Thus the above determination falls between these three authorities, and is in fact about reached by the probable error of the mean of them.

Besides the total length of the rod, the divisions must be considered as giving a value for the cubit. Leaving, therefore, for separate consideration the lesser subdivisions and ends, we will look only to the series of palms. As these were probably copied mechanically from another standard, and were apparently not produced by stepping lengths on the rod, we should ascertain the mean value they give for a Normal scale, and their errors from it. This carefully computed from these palm divisions is 41·390 for the cubit, or 2·956 for each palm; and the average error of the palm divisions is ·007 (the maximum error is ·018), so the probable error of this value for the mean cubit is about ·002. This average error of $\frac{1}{140}$ inch is rather large, but not worse than would probably be made at the present time in such work. By having a standard scale for comparison, hand dividing may be done on a still longer rod with a quarter of the error of this cubit, or even less; but as a mason's measure, this cubit is at least as accurate as modern examples.

The digit divisions are remarkable; the two last fit the Normal scale as accurately as the palms, but in making the divisions 36·195 and 36·922, the scale has apparently slipped away from that end of the rod about ·028; and thus these have an average – error of that amount. The ends appear to have been left rather long, perhaps to allow for wear, being ·026 and ·011 too long respectively, giving an average surplus of ·019. This may be intentional, or may result from being copied from a longer standard than the subdivided prototype, or may be merely an error. In any case, the tolerable equality of the surplus at each end, seems to show that the subdividing was from another standard, and not by stepping successive distances, as the difference is only $\frac{1}{3000}$ of the total length.

In Queipo's Metrology the value of each palm of this example of the cubit is stated to the millionth of a metre, two places farther than really measured, as they are merely reduced from English inches and hundredths, with an occasional half-hundredth. These values are all about $\frac{1}{300}$ too short (their sum being 41·3, as Sir Gardner Wilkinson's statement), but otherwise they agree closely with the series given above; and their mean difference from it (when corrected for their general shortness) is ·011, or but little more than the hundredth of an inch to which they were originally read.

If from the other eight or nine examples of the Karnak cubit the mean cubit was deduced from the subdivisions, and the internal errors of it thus obtained, we should have more knowledge of the accuracy of the earliest known civilisation, a datum of much interest from a scientific and historical point of view. A similar examination of the measures of classical and mediæval times, including our ancient national standards of all kinds, would also give an idea of the accuracy which in various ages, and for various purposes, has been considered to be the utmost requisite; a maximum datum very different to that obtainable from other remains, which only show the amount of accuracy usually employed. As a chapter of the history of science, now so much considered, this subject should not be longer neglected.

Bromley, Kent W. M. FLINDERS PETRIE

The Chemical Society

THE article which appears in NATURE, vol. xiv. p. 125, on the Organisation of the Profession of Chemistry throws doubt on the expediency of effecting the proposed organisation through the instrumentality of a society which has solely occupied itself with the extension and diffusion of knowledge, viz., the Chemical Society. It farther proposes that as it would be a wide departure from the functions which the Chemical Society has hitherto performed to undertake the appointment of a Board of Examiners, the Universities of Oxford, Cambridge, and London should be asked to co-operate in the matter, being already formed examining bodies, which would probably command and deserve greater confidence than a board nominated by a newly formed Institute, or even by the Chemical Society.

On these remarks I beg to offer the following comments:—

1. The Chemical Society never has promoted the acquisition of such knowledge and skill as are necessary for the discharge of such duties as a professional chemist is required to undertake.

2. If the Chemical Society has performed all other functions but this—the fact is no argument against it appointing a Board of Examiners, or of conferring some distinction on those who are capable of acting in the service of the public as chemists; indeed, if this may conduce to the "general advancement of chemical science," the Society, by not taking such steps, is scarcely fulfilling the duties for which it was originally founded, and by opposing any such scheme it may actually retard the progress of chemistry in this country.

3. The writer of the article is apparently unaware of the fact that it would be very difficult to make any examination answer the purpose of testing a man's skill and technical as well as scientific knowledge in a satisfactory manner. An organisation scheme has been designed by a few gentlemen in conjunction with myself, so as to obviate examination as far as possible, or, in other words, to extend the examination over a period of six years. Those of us who are teachers in medical schools, and particularly those who at times have had to take to "coaching" for a livelihood, see the defects of a system which entirely depends upon examination as a test of qualification. Certainly no University examination would have the confidence of professional chemists. There are many business details besides granting certificates of competency which an organisation of chemists would be obliged to undertake, as, for instance, imposing such observances on the members as would tend to suppress objectionable practices which are somewhat too common at the present time.

The *Chemical News* for June 9 contains a sketch of an organisation scheme, and the conditions of admission for original members are there set forth. If the Chemical Society as a body agrees to accept such a scheme, by all means let it do so, but it does not appear clear whether the qualified Fellows of the Society could constitute a separate body, managing their own affairs, within the Society, without the interference of other Fellows not of the same class.

British chemists are now in request all over the world, Japan, India, China, Canada, and California, and some mark of distinction as "chemists" which those who go abroad might carry with them would be valuable to them and enhance the value of the science in this country. WALTER NOEL HARTLEY

Scientific Club, 7, Saville Row, W.

Lectures on Meteorology

IN these days of the rapid development of the standard sciences, and the multiplication of their offshoots into considerable sections nearly as big as their originators, it may not be inappropriate to represent the claims of meteorology for a separate existence apart from others. As geology and mineralogy have been developed out of the natural history of former times, so it may obviously be suggested that meteorology might be detached from natural philosophy with which it has been

hitherto connected, and be taught as a separate science on its own merits and usefulness, and extent of practical application. It is therefore proposed that meteorology might constitute a separate course of lectures, theoretical and practical, at our colleges, where might be expounded its bearings on navigation, agriculture, human health, and engineering. To it might also be attached the sciences of ventilation of buildings, as barracks, factories, and mines, and hydrology, or a knowledge of ocean and sea currents, and ice drifts.

The foundations for such a professorship in scientific materials have, it is suggested, now reached a sufficient weight and bulk as to furnish ample occupation, and to be of universal interest and general application.

Weather observatories, now numerously established, will require superintendents and assistants, captains of ships would be benefited by some scientific knowledge of the winds and waves, and farmers would find meteorology useful for the successful tillage of the soil.

Again, overseers of mines would derive some good from a knowledge of the mechanism of the currents of the air they have to regulate in ventilation, and engineers of waterworks would require to know the variability and extent of rainfall for the sites and construction of their reservoirs.

Finally, the science of the weather is of most importance of all to those who have to fulfil the duties of health officers in our great towns, and climatology is more than ever studied by the physician having to give advice to the numerous invalids who now travel abroad for the sake of restoration of health by change of air and scene.

In order to facilitate the accomplishment of this object, it is suggested that some means should be taken to originate a fund to defray the expenses of such a course of lectures, either in London or Edinburgh, both of which cities have meteorological societies which might lend their influence to promote such schemes of scientific development.

The class of men to whom resort might be suggested for patronage of this proposition would most likely be shipowners, landowners, and boards of health, either for the study of their self-interest or for the benefit of the public. SPES

Edinburgh, June

THE BRITISH ASSOCIATION—GLASGOW MEETING

THE arrangements for the reception of the British Association are fast progressing towards completion. The Executive Committee met on Tuesday, and the following is a brief sketch of the work which has been done:—

Finance Committee.—The total sum subscribed to the Guarantee Fund amounts to £6,559 10*s*.

Museum Committee.—This Committee has arranged as follows:—The Geological Exhibition will be accommodated in the Corporation Galleries, Zoology and Botany in the lower Queen's Rooms, and Archæology, &c., at the University. These exhibitions will be large and complete, and arrangements havebeen made for keeping them open, if desired, for some time after the meeting of the Association.

Local Industries Committee.—This Committee has three sub-committees—one for Machinery, one for Chemicals, and one for Textile Fabrics—and the materials for a highly instructive exhibition are being collected, which will be held in Kelvingrove Museum, where there is already a general museum of considerable size and variety.

Reception Committee.—Already a number of distinguished persons have been invited and have accepted invitations. Among these are the President-designate, Prof. Andrews, of Belfast, who will be the guest of Sir William Thomson, the present President, Sir John Hawkshaw, who, with Lieut. Cameron, the African explorer, will be the guest of the Lord Provost. The Duke of Argyll, one of the Vice-Presidents, will be the guest of Prof. Blackburn.

Arrangements have been made with all the leading railway companies in England and Scotland to facilitate the visits of strangers and their stay in Glasgow. A guide and handbook for Glasgow and the West of Scotland is being prepared under the general editorship of Dr. Blackie.

The following places have been secured for the use of the Association:—The University, where, as at present arranged, all the Sections except the Geographical and Ethnological Section (Section E) will meet, Section E meeting in the large upper hall of the Queen's Rooms. At the University, also will be the Reception and Refreshment Rooms. Kelvingrove Museum.—This will be the receptacle for the exhibitions of machinery, of chemicals, and textile fabrics. Queen's Rooms.—Here will be held an exhibition of the zoological and botanical collections of the district, and here also the meetings of Section E will take place. The upper Corporation Galleries will be filled with a geological exhibition, there being no room at the museum at the University to accommodate more than the Archæological Section, in addition to the permanent and temporary exhibits already arranged there. The City Hall and the Botanic Garden Palace have also been secured for the use of the Association. The Chambers of the Association, where all inquiries may be made, will be found at 135, Buchanan Street.

A great many of the citizens have indicated their wish to receive guests, and a list is being drawn up of expected visitors, from which guests may be selected. Notice of its completion will be given by advertisement in the newspapers.

Excursion Committee.—It has been arranged that excursions will take place on Saturday, the 9th, and Thursday, the 14th of September, to the following among other places:—Arran, Lochlomond, Loch Fyne, and the Holy Loch, Coatbridge, and Paisley. Mr. A. B. Stewart has placed his yacht at the disposal of the Association, as has also Mr. Duncan of Benmore, for dredging expeditions. It is intended that there will be at least one dredging excursion to the Firth of Clyde, or other suitable place. Mr. Duncan will also receive at Benmore a party of 100, who go the round by Loch Fyne, for whom he has arranged a delightful excursion. Mr. Martin of Auchendennan will receive a party at dinner there, and Mr. Campbell of Tulliechewan and Mr. Matheson of Cordale have also intimated their desire to show hospitality to members of the Association visiting Dumbartonshire. Mr. Ellis will entertain a party at luncheon at Coatbridge after inspection of the North British Wireworks, and Sir Peter and Mr. Thomas Coates are expected to do the same at Paisley.

ABSTRACT REPORT TO "NATURE" ON EXPERIMENTATION ON ANIMALS FOR THE ADVANCE OF PRACTICAL MEDICINE[1]

II.

Experimentation with the forms of Lycoperdon giganteum, or common Puff-Ball.

IN 1853, while the study of the art of producing safe anæsthesia was fresh upon me, my attention was directed by my friend, Mr. H. Hudson, to the fact that in the country the owners of bees rob the bee-hive of its contents of honey and wax after they have stupefied the bees by driving into the hive the smoke of the common puff-ball—*lycoperdon giganteum*. It struck me at once that I ought to ascertain whether the stupefying agent which is given off in the smoke would act as an anæsthetic on the higher animals and on man, and whether a new and safer anæsthetic than chloroform was contained in it. The results of this research, some of which I published in the *Association Medical Journal* in 1853, showed that the narcotic agent present is indeed a true anæsthetic, and that all animals may be narcotised by it, but that owing to the mode in which it has to be administered, it cannot conveniently be applied to man. All the lower animals about to be subjected to operations of any kind, surgical

[1] Continued from p. 152.

or physiological, could, I found, be rendered insensible by this agent safely and inexpensively. I invented a room or chamber in which animals could be placed so as to be exposed to the anæsthetic, and I introduced the use of this method of anæsthesia. From time to time during the past twenty-five years, many necessary surgical operations have been painlessly performed on domestic animals under this anæsthesia, and almost all my own physiological experiments which would have been painful have been conducted under it without pain. Some other physiologists have followed me in this procedure, and have introduced the puff-ball narcotising box into their laboratories in order to save pain from experiment. In these ways the simple experimental research derived from the observation on the bees has proved doubly useful.

While these researches were first being pursued a friend of mine came to me in great distress because his splendid and favourite retriever dog had been bitten by a rabid dog and was now stricken with rabies. He asked me to destroy his dog in the kennel, as nobody dared to remove the animal. I carried out the request at once by simply closing the door of the kennel, covering it with a horse-cloth, and letting the clarified and condensed fumes from the burning lycoperdon pass into the kennel. The animal lapsed quickly into sleep and died without a struggle. I believe this was the first time in the history of science in which anæsthesia had been employed intentionally and systematically for the painless extinction of the life of the inferior animals. I shall show in a future note the singular importance of this application.

Research with Carbonic Oxide.

The observation that the smoke of the burning lycoperdon would produce anæsthesia in the higher animals led naturally to an inquiry after the agent that was at work in creating the insensibility. I commenced to make an analysis of the smoke in order to determine the question, but was forestalled in discovery by two other experimenters, the late Dr. John Snow,—so well known for his researches in anæsthetics, and as the author of the water theory of cholera,—and by the late Thornton Herepath, one of our most promising young chemists. These two gentlemen almost simultaneously discovered that the gas called carbonic oxide is present in the smoke of the lycoperdon. This was a new light, and led me to study the action of carbonic oxide on animal life. I found that this agent, a colourless and inodorous gas, produced insensibility in precisely the same way as the purified smoke of the puff-ball. I found that when the combustion of the puff-ball was made so perfect that no carbonic oxide was formed, there was no anæsthesia induced by the purified fumes, and so the fact was rendered clear that the special anæsthetic in the smoke is the gas in question. I estimated also the proportions of carbonic oxide that could be breathed in the atmosphere, and the effects of the gas in larger and smaller proportions on the lower animals and on myself.

Experimentation in Relation to Diabetes from Breathing Carbonic Oxide.

In conducting the observations on the action of carbonic oxide on living bodies, I was led to examine the animal secretions, and to my surprise I found that the renal secretion of an animal subjected to the gas yielded evidence of glucose or grape sugar. The fact was of such importance I was compelled to follow it up until I had quite established it, and had proved that by the inhaling of this active gas, a temporary attack of the disease known commonly as diabetes, which in the human subject is often fatal, could always be artificially induced in the dog. In a further experiment I found that the inhalation of common coal-gas diluted with air would produce the same condition, an effect caused by the carbonic oxide which is always present in coal-gas. The same has subsequently been observed in a human subject accidentally exposed to the gas. The ultimate value of these observations has yet to be proved. When I first published, in the *Medical Times and Gazette*, on March 22, 1862, the fact of the artificial production of diabetes by carbonic oxide, nine years after I had first observed it, it was looked upon rather as a curious than a practical demonstration. I have always felt that though it did not seem to offer any immediate practical result, it must some day be useful in throwing light on the origin, or at least on one origin of a fatal malady. Quite recently Dr. Pavy has published some valuable details on the production of diabetes by the same means, that is to say by making animals inhale carbonic oxide, and he has been able to arrive at some clear ideas on the question of the chemical changes that are involved in the process. We may fully expect to receive from him further valuable information.

I wait a moment at this point to observe that the history of experimental research given in the last note illustrates forcibly the value of what may be called the accidental observations that are picked up in the course of experiment. Who ever would have dreamed that from a practice of stupefying bees in order to rob them of their honey, a practice which has been carried on by the vulgar for many centuries, would come the discovery that the higher animals, and even man himself, can be made to produce glucose, and that they may become afflicted with the symptoms which characterise a destructive disease from a simple perversion in the animal chemistry induced by the smoke of the burning puff-ball.

Experimentation with Oxygen Gas.

The experiments with carbonic oxide led me to a series of experiments with oxygen gas. The late Sir Benjamin Brodie and Mr. Broughton, in their experiments on this same subject, had observed that when animals are placed in pure oxygen they die, with symptoms of sleep, as if they were narcotized, although the products of respiration are removed. Hence for many years oxygen gas, on which we depend for life, was believed to be a narcotic or sedative poison. In my experiments many new facts came out which modified this view. In the first place I found that some animals, such as frogs, will live in oxygen as readily as in common air; that herbivorous animals will live in it if it be kept supplied to them in fresh current, but the carnivorous animals will not live in the pure gas for a long time without becoming drowsy and insensible and without undergoing changes of their blood, which are fatal to life owing to separation of the fibrine within the vessels. The most important observation, however, which I made on the subject of the effects of oxygen, is the following:—I found that a narcotic action of the oxygen is produced, however pure from the products of respiration the oxygen is maintained, whenever it is breathed over and over again by being passed backwards and forwards through the chamber in which the animals breathe it. Subjected three times to this passage through the chamber, though it be purified so fully from carbonic acid that it contains less of this gas than the common air, it fails to support the active life of all common animals excepting frogs. In a word, the oxygen assumes a negative condition in which it will not support living function. In a report on these researches, made to the British Association for the Advancement of Science, at the Oxford meeting in 1860, I defined this state as one in which no new poison was produced, but in which the oxygen lost some principle or property by which in its fresh state it sustained the animal life.

The lessons taught by these observations extend to the human family. They show that if the oxygen of the great atmospheric sea in which we all breathe should from any cause assume this negative condition, it will fail to sustain the active life. They explain the depressing effect of breathing over again the same air in close and badly ventilated rooms. They throw a distinct light on that "epidemic condition" of the atmosphere, which, since

the time of Sydenham has been noticed, but never explained, in which diseases of spreading type extend uncontrolled when once they are started on their course. In the artificial negative atmosphere which I produced in the manner described above, I observed that dead animal and vegetable substances underwent rapid decomposition, and that slight wounds on living bodies became fœtid.

There followed upon these observations other series, in which the effect of the forces of heat and electricity were tried in order to determine whether they would modify the condition of the negative oxygen in respect to its life-sustaining power. The result of these inquiries was to prove that cold added to the negative effect and quickened the narcotism, while a raised temperature, a temperature of 75° F., delayed the narcotism. I also discovered that the passage of electrical sparks through the negative gas restored it to its full activity.

In yet another series of inquiries oxygen, under the influence of the forces of heat and electricity, was rendered active until its sustaining power was destroyed by an opposite process, viz., by the activity with which it entered into combination with the blood. In this manner the action of ozone was observed on animal bodies, and the quickened state of the circulation and over-action which the oxygen in this active state produces were defined. The local action of ozonized air on the air-passages and nostrils in the human subject was tested on Dr. Wood and myself, and the peculiar catarrh and headache which follow the inhalation of ozonized air were described from our own personal experiences.

The whole of these inquiries on the effects of differing physical conditions of oxygen were full of the most useful practical information in reference, if not actually to disease, to the mode in which surrounding atmospheric conditions modify the course of disease. They indicated how men and animals living in the large atmospheric sea are influenced by the action of the great forces of nature on the vital oxygen. They have taught me so much that I could, if I had the means, build a hospital with such appliances for modifying the air, that the course of some diseases might be governed towards recovery by the simple management of the physical conditions of the atmospheric oxygen. In a future and more advanced day of science, this method, the basic principles of which are here sketched out, will be an approved and positive method of treatment. Even now, under the greatest disadvantages, from want of organised plans, I have been able to render useful service to the sick from the experience gained by the experimentation.

BENJAMIN W. RICHARDSON

(*To be continued.*)

THE CRUELTY TO ANIMALS BILL

IN the House of Lords the Government "Vivisection Bill" was discussed in a full Committee on Tuesday. The Marquis of Lansdowne began by a very temperate remonstrance against the Government going so far beyond the recommendations of the Royal Commission on the subject. His speech (which is fairly reported in the *Times*) is by far the best for knowledge and for sense that has yet been made on the Bill, but the provision against which he especially protested—the licensing of places as well as of persons—though warmly supported by Lord Kimberley, still remains part of the Bill. This provision scarcely affects physiologists as such, but may be a means of serious annoyance and hindrance to strictly medical experiments, on, for instance, the contagion of disease or the action of drugs, and would have made the experiments by which Jenner freed the world from the plague of small-pox impossible.

On the first clause Lord Carnarvon stated that the title will be altered from "An Act to Prevent Cruel Experiments upon Animals" to "An Act to Amend the Law relating to Cruelty to Animals," *i.e.*, the Bill no longer pretends to prevent alleged cruelty by scientific men in this country, inasmuch as the charge has not been in a single instance maintained, and only provides that infliction of pain on an animal shall not be screened by the excuse of a scientific object, if the delinquent does not hold a certificate from the Secretary of State that he is a competent person to conduct experiments on animals with all possible humanity and with ability to make them useful.

After some desultory conversation on the definition of the word "animal" (in which one Minister of the Crown committed himself to the opinion that some creatures can feel when their heads are off), the first important amendment was moved by Lord Rayleigh, supported by Lord Cardwell, and accepted, after discussion, by the Ministry. The Bill now, therefore, actually recognises the pursuit of knowledge as equally worthy of respect with that of medicine, and both as entitled to some small share of the immunity accorded to the pursuit of wealth or of amusement. In other words, while the members of the House of Lords have all their lives been vivisecting their animals without anæsthetics *for fun*, they are now pleased to allow physiologists to do the same under many limitations for the advancement of science. This admission was actually opposed by Lord Coleridge in a speech which was forensic and sentimental in the worst sense of the words.

In the fifth clause, exempting cats and dogs from all experiments (even when painless) if undertaken for physiological or medical purposes, the Government accepted the amendment of the Earl of Harrowby, to include hares, mules, and asses under the same provision; but admitted a proviso for these animals being available on special certificate from the Secretary of State when absolutely necessary for some special investigation. On this clause the Earl of Airlie made a sensible speech, but he was not supported by the peers on the Royal Commission, whose report was implicitly condemned. The other clauses were rapidly run through, the Earl of Portsmouth making a successful attempt to obtain some recognition of the necessity of studying the diseases of animals as well as of man. The absurd regulation which, apparently by an oversight, subjected registered and inspected laboratories to the police visitation intended to prevent experiments in unregistered places, was amended without discussion, and the Bill is now probably in the form in which it will be laid on the table of the House of Commons.

Some of its most glaring contradictions and absurdities have been remedied; and, if worked by a reasonable Home Secretary, competent inspectors, and physiologists as humane as the ten or twelve gentlemen who now possess laboratories in the three kingdoms, it will probably do good. But the whole discussion shows the folly of legislating to satisfy unreasoning clamour, and the hopelessness of Parliament dealing in detail with a subject of which almost all its members are profoundly ignorant.

The reasonable plan would have been to register laboratories, and give certificates to persons duly recommended; to inspect them carefully; to withdraw the licence on any abuse being proved; and then to extend "Martin's Act" so as to apply to all cruelty to animals, whether domestic or wild, whether performed with a bad object or a good one, so long as the delinquent did not hold a certificate. This would have been in accordance with the recommendations of the Royal Commission, would have given far less trouble to Home Secretaries and to physiologists, and would have been a more effectual provision against cruelty. But Parliament has nothing important to do, the Government are in want of popular applause, and very few have the patience or the candour to learn the true state of the case; so that we must be content to hope that the Bill will do less harm than was at first inevitable.

A MUSEUM FOR INDIA AND THE COLONIES

AT the meeting of the International Congress of Orientalists in London in 1874, Dr. Forbes Watson read a paper in which he described (see NATURE, vol. x. p. 421) the plan of an Indian Museum, Library, and Institute. This paper was afterwards published (see NATURE, vol. xi. p. 413). Dr. Watson has just published a pamphlet[1] in which the proposed India Museum and Institute has very naturally expanded into an Imperial Museum for India and the Colonies. What Dr. Watson proposes is that on the site of the old Fife House, on the Victoria Embankment, at the Thames end of the new Northumberland Avenue, a large and suitable building should be erected, to consist of two divisions, one devoted to the interests and products of India, and the other to those of the various British Colonies. The library and collections which already exist in connection with India are acknowledged to be of great value and importance, and their location in an appropriate building in a central position would greatly increase their usefulness. The arrangement at South Kensington is of course only temporary. Now that Dr. Watson has proposed a plan for an institution which would do for the other colonies what the India Museum and Library attempt to do for India, one wonders why steps have not been taken long ago to supply what appears to be a real want. The subject has, however, engaged for years the attention of those who take an active interest in the Colonies, and several of the Colonies have gone so far as to vote money for the establishment of a Colonial Museum in London. Few people realise the importance of the Colonies to Britain; their extent, population, and the value of their commercial transactions are forcibly exhibited by Dr. Watson in his pamphlet, which we would recommend those to read who wish to have some idea of the value of the Colonies to the mother country. From a scientific point of view such an institution as is proposed would be of great interest and value. British Colonies are to be found everywhere over the surface of the globe, and embrace all climates and every variety of natural productions. Students of natural science would find a properly arranged collection of our colonial productions of great use, especially if combined with a proper library, and no better method could be devised of educating the public generally as to the extent, importance, physical condition, and natural products of "Greater Britain."

Dr. Watson shows that from every point of view, political, commercial, and scientific, the establishment of such an all-embracing Imperial Institute would be of the greatest benefit both to this country and her Colonies, and would no doubt serve to bind them more closely together. We are sure his scheme needs only to be known in its details to recommend itself to the public, and we are confident that if steps were taken to move the proper quarter, the accomplishment of the scheme would be only a question of time. The Colonies themselves are willing to bear a share of the expense necessary, and it would only be fair that this country, through the Government, should meet the Colonists as far as it can.

Into the details of Dr. Watson's plan we have not space to enter. There would, as we have said, be virtually two museums under one building. In the division devoted to the extra-India Colonies, the museum representative of each Colony would be kept distinct, so that the whole would be rather a federation of museums than one museum. Then there would be a Colonial Library and Reading-room; provision would be made for giving a home in the Institution to the Asiatic Society and the Colonial Institute; by means of "Trade Museums," a full representation would be given of Colonial produce, and in the proposed institution the offices of the various Colonial agents now dispersed over London could be established. The advantages of such an Institution are well summed up by Dr. Watson in the following paragraph:—

"The combined India and Colonial Museums, established according to the above plan, would in every way become a living institution worthily representing the past history and the present resources of the British Empire throughout the world. Such an institution would afford not only exhaustive materials for study and research, but would likewise be suitable for reference by the Indian and Colonial authorities, by men of business or of letters, and by officials or emigrants intending to proceed to India or the Colonies. Thus it would be instrumental in furthering actual work or business, whether scientific, political, or commercial. At the same time, through its co-operation with the Asiatic Society and the Colonial Institute, through its reading-room, its lectures and publications, through the Trade Museums and other typical collections distributed all over the country, as well as throughout the most important places in India and the Colonies, all the information would be rendered available to the whole Empire."

[1] "The Imperial Museum for India and the Colonies." By J. Forbes Watson, M.D., &c., Director of the India Museum. (Allen and Co.)

FERTILISATION OF FLOWERS BY INSECTS[1]

XIV.

Flowers Fertilised by the Wings of Butterflies.

IN my former articles many plants are referred to which are fertilised by butterflies, whose proboscis, head, legs, or whole underside comes into contact with the anthers and stigmas of the flowers visited; but hitherto no plant has been known which is fertilised by the fluttering wings of butterflies. My brother, Fritz Müller (Itajahy, Prov. St. Catharina, Brazil), has lately observed a species of *Hedychium* (Piperaceæ) whose bright red scentless flowers, opening in the morning, are wonderfully adapted to this manner of fertilisation. I give his description, as far as possible, in his own words.

The flowers of this Hedychium are collected in groups of 4–6, which are enveloped by a common bract; in every group only one flower is ever developed at the same time, this commonly fading before the next one has opened. The groups of flowers are arranged in alternating whorls, each consisting of three groups (Fig. 89); the spike thus formed reaches 0·25 metre in length, and is composed of six longitudinal rows of flowers, each row containing about ten.

The corolla-tubes, about 0·03 m. long, 0·5 and 1 mm. wide, are completely enclosed by the very firm common bract; moreover, each by its calyx closely embracing it, by its special bract and partly by the bracts of the older flowers of the same group. Thus the honey, which on the morning of the first day fills up about one-third, on the morning of the second day about two-thirds of the length of the tube, is excellently protected from being stolen by piercing the tube, of which some Apidæ, especially Hylocopa, are exceedingly fond. The flowers are placed nearly horizontally, the stamen a little above, the lip a little below a horizontal plain intersecting the entrance of the honey-tube. The lip, which in other species of Hedychium is expanded level and almost sessile, is here long stalked, and rolled up into a channel of 0·01 m. in length provided with a funnel-shaped entrance. The entrance of the lip-channel (Fig. 89 *A*) being about equally distant from the two longitudinal rows of anthers and stigmas Fig. 89 (*B*, *C*) between which it is situated, both rows are alike struck by the wings of the butterflies flying on and off.

The filament is 47 mm. long on the forenoon of the first day and somewhat bent upwards, so that the pollen-covered side of the anther looks outwards or even a little

[1] Continued from vol. xiii. p. 294.

upwards (hence the stigma looks upwards or even obliquely backwards); on the morning of the second day it is 50 mm. long, straight, and the stigma looking forwards; by the morning of the third day the flowers bend aside and wither. Consequently on the first day the anthers, on the second day the stigmas are more liable to be struck by the wings of the butterflies, although the stigmas seem to be capable of being pollinated already during the opening of the flower. The pistil, as in other species of Hedychium, is inclosed in a completely closed channel of the corolla tube (Fig. 90) and of the filament (Fig. 91); the funnel-shaped stigma (Fig. 92), secreting plenty of fluid and bordered with hairs (Fig. 93), slightly overtops the anther (Fig. 89, *st.*).

By the morning of the second day all bees and butterflies with a proboscis of more than 10 mm. long would be enabled to obtain at least a little portion of the very sweet honey from out the opening of the corolla-tube; whereas from the more conveniently situated opening of the lip-tube the full store of honey can be reached only by a single species of the butterflies of Itajahy (as far as their proboscides have been measured

Fig. 89.—Hedychium. Two alternating whorls, each consisting of three groups, each group containing from four to six flowers, of which only one or two are developed. Half natural size. 1. Flowers on the first day. 4. Flowers on the second day. In most flowers only the lip and the stamen with the stigma are drawn. *a*, anther; *st*, stigma.

by my brother), namely, the males of *Callidryas Philea*, with a proboscis from 36 to 43 mm. long.[1]

This was indeed the most assiduous of all visitors. It was always sucking out of the lip. Scarcely less frequently were the flowers visited by *Callidryas Eubule* ♂, always sucking in the same way, with a proboscis from 27 to 30 mm. long (a female, caught on these flowers, had a proboscis only 24 mm. long). *Callidryas Trite* ♂, on the contrary, with a proboscis 18 to 20 mm. long, seems always to suck immediately out of the corolla-tube. *Callidryas Statira* ♂ (19 to 21 mm.) mostly sucks in the same way; but sometimes also from out the lip. *Callidryas Argante* being very rare during the flowering time of this Hedychium (towards the end of January) was only occasionally seen visiting its flowers, and it was not observed in what way it reached the honey. Dark yellow, orange, scarlet, red, are the favourite colours, not only of the Callidryas but likewise of the *Agraulis* (*Dione*) and of some

[1] The proboscis of the female seems to be not so long; in two females measured by my brother it did not exceed 35 mm.

species of *Papilio*; of the former, *Agraulis vanillæ* (proboscis 15 mm.) visited the flowers several times, but soon flew away again. Of species of Papilio, *P. Thoas* (26 mm.) appeared especially frequently, as also several times *P. Palydamas* (24-25 mm.), *P. Cleotas* 22-23 mm.) three times, and once *P. Protodamas* (?) (22 mm.); these mostly fluttered upwards along the rows of flowers without settling down; it was not distinctly seen from which opening they obtained the honey.

Another adaptation of the flowers to cross-fertilisation by butterflies must be mentioned. A wing of a butterfly is a tolerably smooth plain, moving rapidly when flying; the pollen-grains of Hedychium are likewise smooth; these peculiarities are ill adapted to each other; but this inconvenience is removed by the anthers not bursting, but their anterior-surface dissolving into a layer of slime which covers the pollen-grains and glues them to the wings.

Of Apidæ my brother once saw *Xylocopa*; it attempted to suck from the lip, but after having made some fruitless trials flew away again. He repeatedly met with *Bombus violaceus* and *Cayennensis*, rarely, however, compared with their frequent visits to other flowers, for instance, the neighbouring bushes of Buddleia. They sucked from out the corolla tube. *B. violaceus* was several times observed to alight on the lower flowers of a longitudinal row, climbing from there up the row more or less completely, then flying to another spike. In consequence of this systematic manner in which the most intelligent bees explore the flowers of a plant, the fertilisation by bees of a plant with such a number of flowers as our Hedychium

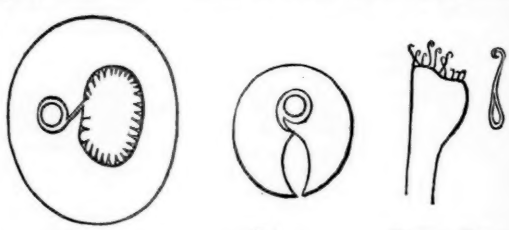


Fig. 90. Fig. 91. Fig. 92. Fig. 93.

Fig. 90.—Transverse section of the corolla-tube, 15 : 1. Fig. 91.—Transverse section of the filament enclosing the pistil. Fig. 92.—The stigma bordered with hairs. Fig. 93.—A single one of these hairs.

must be by far less advantageous than the fertilisation by butterflies. Suppose a specimen of this Hedychium bearing twenty spikes, each with fifty flowers, a humble-bee would be likely to visit 1,000 flowers without effecting a single cross-fertilisation between different plants, consequently without any profit for the plant, which is sterile with its own pollen. On the contrary, on flowers copiously visited by butterflies, the same butterfly will rarely visit a greater number of flowers of the same plant continuously; and this holds good, not solely, as Delpino has already remarked, with females which are followed by the males. On a Hedychium, males of Callidryas only were flying (females being then very rare), but, nevertheless, as soon as any butterfly was approached by another of the same or even of a different species, it flew up, ran and whirled with it about in the air, and then alighted commonly on another bush.

Lastly, there appeared repeatedly several species of humming-birds, one of which was so absorbed in sucking the honey that it could be caught with a net, which my brother had never before succeeded in doing. In the corolla-tube of this Hedychium small insects have never been found by my brother; the perseverance with which the humming-birds made use of its flowers proves, therefore, in case such a proof should still be needed, that these birds were here searching for honey.

It may be remarked in addition that humming-birds are far less exclusively attracted by the bright red colour of flowers than Callidryas; and, as these butterflies are

those which are found in greatest numbers in Itajahy (*Acræa Thalia* only perhaps equalling or even surpassing them in number), the frequent occurrence of orange-coloured or scarlet flowers in that country is probably less an adaptation to humming-birds than to this fondness of Callidryas. The red Salvia, Canna, the orange-coloured species of Lantana, *Epidendron cinnabarinum*, &c., are assiduously visited by Callidryas.

Lippstadt, May 13 HERMANN MÜLLER

LOAN COLLECTION OF SCIENTIFIC APPARATUS

SECTION—MECHANICS

PRIME MOVERS[1]

WE now come to Newcomen, who I think may fairly be looked upon as the father of the steam-engine in its present form. No. 1,942 is a model of his engine, which is further illustrated by a rare engraving (of 1712), the property of Mr. Bennet Woodcroft.

Here we have the steam boiler, the cylinder, the piston and rod, the beam working the pumps in the pit, the injection into the cylinder and the self-acting gear, making altogether a powerful and an automatic prime mover.

That conscientious writer, Belidor, to whom I have already frequently referred, says, that he hears of one of these machines having been set up in the water-works on the banks of the Thames at York Buildings. I may say to those who are not aware of it, that those works were situated where the Charing Cross Station now stands. On a Newcomen engine being erected in France at a colliery at Fresnes, near Condé, Belidor paid several visits to it in order that he might understand its construction thoroughly, and be thereby enabled to explain it to his readers. He has done so with a minuteness and faithfulness of detail, in description and in drawings, that would enable one to repeat the engine. This engine had a 30-inch cylinder with a 6-feet stroke of the piston and of the pumps. The boiler was 9 feet in diameter and $3\frac{1}{2}$ feet deep in the body; it had a dome which was covered with masonry 2 feet 6 inches thick to hold it down against the pressure of the steam. It had a safety valve (the Papin valve) which Belidor calls a "Ventouse," and says that its object was to give air to the boiler when the vapour was too strong. It had double vertical gauge cocks the function of which Belidor explains; it made fifteen strokes in a minute; and he says that being once started it required no attention beyond keeping up the fire, that it worked continuously for forty-eight hours, and in the forty-eight hours unwatered the mine for the week, whereas previously to the erection of the engine the mine was drained by a horse-power machine, working day and night throughout the whole week and demanding the labour of fifty horses and the attendance of twenty men to keep the water down. I should have said that the pumps worked by the steam-engine were 7 inches bore and were placed 24 feet apart vertically in the pit which was 276 feet deep, and that each pump delivered into a leaden cistern from which the pump above it drew.

After having given a most accurate description of the engine, Belidor breaks out into a rhapsody and says (I will give you a free translation) "It must be acknowledged that here we have the most marvellous of all machines, and that there is none other of which the mechanism has so close a relation to that of animals. Heat is the principal of its movements; in its various tubes a circulation like that of the blood in the veins is set up; there are valves which open and shut; it feeds itself, and it performs all other functions which are necessary to enable it to exist."

Smeaton employed himself in perfecting and in properly proportioning the Newcomen engine, but it was not until James Watt that the next great step was made; that step was as we all know the doing away with condensation in the cylinder, the effecting it in a separate vessel and the exclusion of the atmosphere from the cylinder. These alterations made a most important improvement in the efficiency of the engine in relation to the fuel consumed; but they were so simple that I doubt not if examiners into the merits of patents had existed in those days Mr. Watt would have had his application for a patent rejected as being "frivolous." We have here from case No. 1,928, a model made by Watt which appears to be that of the separate condenser and air-pump; we have also 8B which is a wooden model made by Watt of a single acting inverted engine, having the top side of the cylinder always open to the condenser, and a pair of valves by which the bottom side of the piston can be put into alternate connection with the boiler and with the condenser, the contents of which are withdrawn by the air-pump. 3B from the same case is a model of a direct acting inverted pumping engine, made in accordance with the diagram 8B. 1B is a model of Watt's single acting beam pumping engine, while 2B is a model of Watt's double acting beam rotary engine. 10B from the same case is Watt's model of a surface condenser. To Watt we owe, condensation in a separate vessel, exclusion of the air from the cylinder, making the engine double acting, employment of the steam jacket, and employment of the steam expansively, the parallel motion, the governor, and in fact all which made Newcomen's single acting reciprocating pumping engine into that machine of universal utility that the steam-engine now is, and not only so, but Watt invented the steam-engine indicator which enables us to ascertain that which is taking place within the cylinder and to see whether or not the steam is being economically employed. I have on the table before me a very excellent model of German manufacture, No. 2,137, illustrating an inverted direct acting pumping engine in its complete form, and I have also a model of French manufacture, the cylinder and other working parts of which are in glass; this shows a form of Watt rotary beam condensing engine at one time in common use.

I do not say, however, that Watt was the first to make the suggestion of attaining rotary motion from the power of steam. Leaving out of consideration Hero's toy, Papin, as I have remarked, hoped to get rotary movement second-hand by working a water wheel with the water that had been raised by his steam-engine; moreover, as early as 1737, Jonathan Hulls proposed to obtain rotary motion from a Newcomen engine and to employ that motion in turning a paddle-wheel, to propel a tug-boat which should tow ships out of harbour, or even against an adverse wind. I have before me one of the prints of his pamphlet and in order that you may better appreciate his invention I have put an enlarged diagram upon the wall, and I think I may take this as the starting-point for saying a few words about the steam-engine as a prime mover in steam vessels.

We have in the collection, No. 2,150, Symington's engine tried upon the Lake at Dalswinton in 1788. Here a pair of single acting vertical cylinders give, by the up and down motion of their pistons, reciprocating movement to an overhead wheel; this wheel gives a similar motion to an endless chain which chain is led away so as to pass round two pairs of ratchet wheels loose upon two paddle shafts. By the use of a pair of ratchets the reciprocations of the chain are converted into rotary motion in one direction only, and that the driving direction of the two paddle wheels placed one behind the other. Symington's arrangement for obtaining the rotary motion always in one direction of his two paddle-wheels is very similar to that proposed by Jonathan Hulls for his single stern-wheel. Want of time forbids me to do more than just to allude to the names of Hornblower and Wolff in connection with double cylinder engines, engines wherein the expansion of steam is commenced in one cylinder and continued in another and a larger one.

I wish to say a few words which will bring before you the changes that have been made within a very few years in the construction of the marine engines. I may observe that when I was an apprentice the ordinary working pressure of steam, except in the double cylinder engine, was only 3 lbs. above atmosphere, and that there was in a marine boiler more pressure on its bottom when the steam was down, due to the mere head of water in the boiler, than there was pressure in the top when the steam was up, due to the force of the steam; whereas now condensing marine engines work commonly at 70 lbs., and there is a boat under trial where the steam is, I believe, as high as 400 lbs.

To those who are curious on the subject, I would recommend a perusal of two blue books, one being the evidence taken before a Parliamentary Commission in 1817, and the other before a Parliamentary Committee in 1839; they will find there the weight of evidence to be that the only use of high pressure steam is to dispense with condensing water, and that as a steamboat must always have plenty of condensing water in its neighbourhood, no engineer knowing his business, would suggest high pressure for a marine engine.

I have before me a model of a pair of engines which, although

[1] Address delivered by F. J. Bramwell, C.E., F.R.S., one of the vice-presidents of the Section, May 25. Continued from p. 161.

they were made not so very long ago (for I saw them put into the ship), have nevertheless an historical interest. This model shows Maudslay's engines of the *Great Western*, the first steamer built for the purpose of crossing the Atlantic. I think I am right in saying that 7 lbs. steam was the pressure employed in that vessel, and in order to extract the brine from the boiler it was necessary to use pumps as the pressure of the steam was not sufficient to expel the brine and to deliver it against the pressure of the sea.

Time does not permit of my touching upon the various improvements in boilers, condensers, expansive arrangements, and other matters which have gradually been introduced into our best engines for land and for ocean purposes. I have hung upon the wall a rough diagram showing a pair of oscillating engines as applied to driving a paddle steamer, and another showing a pair of inverted compound cylinder engines to drive a screw propeller; a model of such a pair of engines with surface condensers and all modern appliances (being Messrs. Rennie's engines for the P. and O. Company's S.S. *Pera*, by which I have had the pleasure of travelling) is now before me.

I will conclude this part of the subject by saying that to the combination of science and sound practice is due the fact of the consumption of coal having been reduced from 5 lbs. per gross indicated horse-power per hour to an average of $2\frac{1}{4}$ lbs. and, in exceptional instances, to as small a quantity as $1\frac{1}{4}$ lbs. per horse per hour.

Let us now devote a little of the time that is left to the consideration of the locomotive on the common road as well as on the railway. I have before me No. 2,145, a model of the actual engine of Cugnot, in the Conservatoire des Arts et Métiers, which, in 1769, journeyed—slowly, it is true, but did journey and did carry passengers—along the roads in Paris.

It is a most ingenious machine; it has three wheels, and the motive power is applied to the front, the castor, or steering wheel, so that engine and boiler turn with the wheel precisely as, within the last few years, Mr. Perkins has caused the engine and boiler to turn with the steering-wheel of his three-wheeled common road locomotive. The steam causes the pistons in a pair of inverted single acting cylinders to reciprocate, and their rods, by means of ratchet wheels, give rotary motion to the castor wheel, and thus propel the carriage. I think there is no doubt but that we must look upon this engine of Cugnot as the father of steam locomotion, as we must regard Symington's engine as the parent of marine propulsion. I have before me No. 1,926, Trevethick's engine of 1802; I have also before me a Blenkinsop rail, one that has been in actual use for many years, provided, as you will see, with teeth, into which a cogged flange on the side of the driving-wheel is geared to insure that tractive force should be obtained. This plan has been revived, within the last few years, to enable the steam locomotive to climb the Righi. A sketch of the Righi engine and rail is on the wall. It will be seen that the teeth instead of projecting from the side of the rail, are ranged between two parallel bars like the rungs of a ladder.

On the ground-floor of the exhibition we have the veritable "Puffing Billy," an engine which began work in 1813, and got along without the aid of cogs by mere adhesion upon plain rails; it is a rude-looking machine, but it laboured up till the date of the last Exhibition, doing its work for forty-nine years on the railway belonging to the Wylams Colliery, and, as tradition says, interesting George Stephenson, who, as a boy, saw it in daily operation.

On the ground-floor, also, we have 1,954, the "Rocket," with which seventeen years after the starting of "Puffing Billy" George Stephenson carried off the prize in the Manchester and Liverpool Railway competition. The leading particulars of this engine are as follows:—A pair of $7\frac{1}{2}$ inch cylinders 1′ 5″ stroke, placed at a slight inclination driving 4′ 6″ wheels, the boiler, multi-tubular, having twenty-four three and a half-inch tubes, while the fire is urged by the waste blast. Before alluding to this I ought to have mentioned that in one of the Blue Books to which I have called your attention—that which gives the evidence before the Commission in the year 1817—there is a statement by a witness that in those parts there are machines called locomotives, &c.

Once more I am compelled to say that time will not admit of my entering into any detail in respect of the modern locomotive, except to remark that by the aid of excellent boilers, of high-pressure steam (140 lbs. to the inch) of considerable, although rather imperfect expansion effected by the link motion, there is provided for the use of our railways a machine which in the "passenger" form is competent to travel with ease and safety sixty miles an hour, and in the "goods" form is competent to draw a load of 800 to 1,000 tons, and to attain these results with a very commendable economy in fuel. I have put on the wall two diagrams of locomotives of the convenient form for local traffic that we call tank engines, and I have before me No. 1,957*a*, a most beautifully made sectional working model of a Russian six-wheeled "goods" engine.

Within the last twenty years another description of steam-engine has acquired a prominent and important place among our prime movers; I allude to the portable engine, or to the portable engine in its more complete form of a self-propelling or traction engine. The general construction of these machines borders closely upon that of the locomotive. Very great attention has been paid to all their details, and the Royal Agricultural Society of England, by their excellent arrangements for periodical trials, have stimulated engineers to devote their best energies to the subject. No. 1,942 is a model of one of Aveling and Porter's common road traction engines, capable also of acting as a source of power for driving farm-yard machinery or for effecting steam-ploughing. Upon the wall I have placed rough diagrams of another kind of traction engine—a kind wherein india-rubber tires are used; this is manufactured by Messrs. Ransome, Sims, and Head, and I have also placed there diagrams of the ordinary portable engine and of another most useful kind of portable engine, viz., the steam fire-engine. I have there likewise a sketch of Hancock's common road steam coach, which for so many months regularly plied for hire from the Bank to Paddington in opposition to the ordinary horse omnibus. Hancock's carriage was a vehicle which, in my judgment, has never since been surpassed, and I am sorry to say never to my knowledge equalled as regards the various points which should be attended to in making a steam carriage to circulate safely among horse-traffic.

There is another way in which steam may be employed as a prime mover. We saw that water in the form of the "Trombe d'eau" could be caused to induce a current in air and thereby to blow a forge fire, and that a rapid stream induces a current in other water, and thus drains marshy lands. Similarly steam can be caused to induce a current in water and thereby impel the water so as to raise it to a height or to force it as feed-water into a boiler against a heavy pressure. When used for a mere pumping apparatus, such a mode of employing steam is very wasteful, because the steam is condensed by the water in large quantities and the water is needlessly heated at the expense of the steam; but when used in feeding a boiler into which, thus, the whole of the heat is taken, this objection does not apply. By means of that most elegant and scientific apparatus, the Giffard injector, it is possible, by a jet of steam, to economically induce a current in surrounding water, powerful enough to take the condensed steam itself and the water into the boiler from which the steam had previously issued. No. 1,976, which I have before me, is a sectional model of a Giffard injector.

I believe it was I who first gave a popular explanation of the principle of action of the Giffard injector, and although a scientific congress is probably not the place for a popular explanation, I will venture to repeat it. The principle may be summed up in one word, "concentration." The steam that issues from an orifice of an area of 1, when condensed, has a sectional area (according to the original pressure of the steam) of only $\frac{1}{200}$th or $\frac{1}{400}$th or $\frac{1}{800}$th as the case may be, thus the velocity remaining the same and the weight the same, the energy of the steam issuing from an area of 1, is concentrated 200, 400, or 800 times upon the area due to the smaller transverse section of the liquid stream.

This concentration of energy is far more than sufficient to enable the fluid stream to re-enter the boiler from which the vaporous stream started, and so much more than sufficient, that it may be diluted by taking with it a certain quantity of water, which was employed in the condensation of the steam, and is required for the feeding of the boiler.

With a view to obtaining economy in fuel many attempts have been made to employ some other agent than steam as the means of developing the power latent in fuel, but it is imperative that I should dismiss these with a mere enumeration. A very interesting engine of this kind (because, excluding Hero's toy and smoke jacks, it is so far as I know the first proposition for obtaining rotatory motion by the aid of heat), was the fire wheel of M. Amonton, of which an account is to be found in the first volume of the "French Academy of Sciences," for the year 1699. On referring to that volume I do not see that it is stated

in terms, the machine was ever put to work, although it is said that M. Amonton made many experiments to convince the Academy of the practicability of his invention. M. Amonton proposed to have a metallic wheel revolving on a horizontal axis; the outer rim of the wheel was to be divided into a number of separate air cells, each of which had a channel so as to communicate with other cells, water-cells, arranged round the wheel nearer to the centre than the air-cells; the air-cells as they passed over a fire were to be heated, and the air was to drive this water up to one side of the wheel, so as to keep that side always loaded, and thus give the wheel a tendency to revolve. The cells after leaving the neighbourhood of the fire were to be cooled by passing through water to re-contract the air ready for the next operation.

No. 1,940, which is before me, is a model of Stirling's hot-air engine, but time does not remain to describe it.

Besides hot-air engines, we have had engines working by the explosion of gunpowder, and others working by the explosion of gases. No. 1,945 is Langen and Crossley's gas engine, from which I believe extremely excellent results have been obtained.

I will now ask you to look at a tabular statement which shews the consumption of fuel in some agricultural engines, when under trial, expressed in pounds per horse-power per hour, and also in millions of pounds raised one foot high by the consumption of 1cwt. of coals. I told you how excellent were the results at which our agricultural engineers had arrived; you will see that one of those machines, working with 80lbs. steam, and of course without condensation, has developed, not a gross indicated horse-power, but an actual dynamometrical horse-power, for 2·79lbs. of coal per horse per hour, giving a duty of as much as 79½ millions. This high result was obtained by the excellence of the boiler and of the combustion, as well as by that of the engine. If you look at the column of evaporation you will find that as much as 11·83lbs. of water were converted from the temperature of the boiling point into steam by the combustion of 1lb. of coal; this was due, not to the merits of the boiler alone, but to the extraordinary ability of the stoker, and to the care and labour bestowed, a care and labour far too expensive to be employed in practice. But should not we engineers endeavour to ascertain whether we cannot by mechanical means, practically, with certainty and cheapness, procure an accuracy of combustion as great, or even greater than that which can be got by the almost superhuman attention of a highly-trained man, who at the end of four hours of such work is utterly exhausted? Many forms of fire-feeders have been attempted and used with more or less success, but I cannot help thinking that in order to obtain the accurate proportioning of air and fuel, by which alone we can get efficient and economical combustion, we shall have to turn our attention in the direction of dealing with the fuel in a comminuted state, either by converting it into gas, as is done by our president, Dr. Siemens, by availing ourselves of liquid fuel, or by employing the process of Mr. Crampton, and making the fuel into an impalpable powder, that may be driven into the furnace by the air which is there to consume it.

By these, and by other means, we may hope to improve combustion. By strict attention to the proportioning of the parts of the boiler we may hope to make the best use of this improved combustion. By higher initial pressure, by greater expansion, and by the general employment of condensation, wherever practicable (and by the use of the evaporative condenser there are very few cases in which it is not practicable), we may trust that the steam-engine, even on its present principle, will be rendered more economical than it has ever yet been, and may give us more than that one-eighth or one-ninth of the total force residing in the fuel which now alone we get under the very best and most exceptional conditions. A large loss, however, must with steam-engines, as we now know them, always be incurred. We cannot hope to deal with initial pressures and temperatures corresponding with steam of a density equal to that of water, nor to carry expansion down to the point where ice would be formed in the condenser. But wonderful as the steam-engine is, worthy as it was and is of Belidor's eulogium (which I read to you), we know it is not the only heat motor, and we are aware that there are other forms of such motors which, theoretically at all events, promise higher results.

By improvements in the existing steam-engine, by the invention and development of other heat motors, by the employment of the power of water and of wind, either as principal motors or as auxiliaries, we may look to further progress in the machines—the subject of my address—"Prime Movers."

I have brought before you, of necessity hastily, and therefore (and also on account of my own incapacity for the task) imperfectly, the leading improvements which have been made in prime movers from the date of the water-wheels of Vitruvius to the best-devised steam-engines of our own day. These improvements have been effected by men like Papin, Savery, Newcomen, Watt, Symington, Stephenson, and others, who were not mere makers of engines, but were men full of an ardent love of their noble profession, who followed it because of the irresistible attraction it possessed for them; followed it from their boyhood to their grave, and in that very following found their great reward. These men undoubtedly possessed that combination of science and practice, which combination, Dr. Tyndall has told us, is necessary if either science or practice is to continue to live; for, to use his expressive language, without this combination they both die—die of atrophy; the one becomes a ghost, the other a corpse.

We have every reason to believe that this combination will rapidly become even more fully developed, not only in the engineers of the present day, but in those of the next and of succeeding generations, and to such men as these we may trustfully leave the continued improvements of prime movers, resting content with the knowledge that a more general application of these machines must of necessity follow such improvements, and that the day will soon dawn when in no civilised country will there continue to be the temptation to employ intelligent humanity in the brutal labour of the turnspit, or of the criminal on the treadwheel.

OCEAN CIRCULATION[1]

THE present theories with regard to ocean circulation do not appear to account for many of the phenomena with which we are acquainted; and my object in this paper is to state very briefly my own opinions, with a view to provoking discussion, and, in this way, to forward the knowledge of a very difficult but interesting subject. I believe that there are at the present moment two rival doctrines, viz.:—

1. One which attributes all currents to the influence of the winds.

2. Another which attributes all ocean currents to gravitation.

I entirely disagree with the first doctrine, and shall address my remarks to the second. I quite think that ocean circulation is the result of gravitation, but, contrary to what I believe to be the present opinion, I hold that the cold feeding streams flow in a wave from the surface of the Polar oceans, and not from the bottom.

The points that I wish particularly to suggest for consideration are as follows:—

1. That all ocean currents run from a higher to a lower level.

2.[2] That the upward pressure produced in the equatorial regions by the constant inflow, at the bottom, of water from the Polar regions owing its high specific gravity to its contraction from cold; and, *vice versâ*, the constant inflow at the bottom of the Polar regions, of water flowing from the equatorial regions and owing its high specific gravity to its salinity, must, these streams flowing from a higher to a lower level, tend to elevate the lighter surface-water and drift it down a slightly inclined plane as a surface-current.

3. That the primary cause of the origin of all ocean currents is the change in the specific gravity of sea-water from one of the following causes, viz.:

(*a*) Evaporation; the vapour arising from the surface being fresh, and leaving its saline constituents behind it.

(*b*) The excess of precipitation over evaporation, particularly in the Polar seas, which by admixture with the surface-water increases its freshness.

(*c*) The expansion of surface-water through heat.

(*d*) The contraction of sea-water through cold.

It is generally admitted that currents of both air and water flowing from the equator to the poles having an excess of easterly momentum due to the velocity of rotation of the earth's surface in low latitudes as compared with the lesser velocity in high latitudes,[3] must outstrip the earth's motion, and consequently

[1] More particularly with reference to the North Atlantic Ocean, being an abstract of a paper read to the Caterham Literary Society in March last.

[2] I hold it to be impossible that you can have any such thing as an ocean level unless the different strata or layers of water from the equator to the poles are not only isometrical and isothermal, but are also of equal specific gravity; whereas the known ranges of variation of both temperature, salinity, and depth of different strata of sea-water vary much in different places and in different oceans. There is a constant disturbance of equilibrium, and the constant effort to restore and equalise it produces the currents.

[3] The rotatory velocity of the earth's surface being about 1,440 feet per second at the equator, 720 feet per second in 60° of latitude, and decreasing to zero at the poles.

flow in an easterly direction; and, on the other hand, currents of both air and water flowing from the poles towards the equator must for the same reason lag behind, and consequently appear to flow in a westerly direction. From this I argue that the cold currents from the Arctic regions to the equator do hug the western shores, and therefore cannot possibly supply the cold streams on the eastern side of the North Atlantic Ocean, south, at all events, of 50° of lat.; but that the supply must come from the Antarctic Ocean; and, on the other hand, from the same cause, that the cold water on the eastern side of the South Atlantic Ocean is water from the Arctic Ocean which underflows the equatorial stream, and as it approaches the African coast, has a portion of its stream thrown upwards towards the surface, which accounts for the surface-water of the equatorial stream near this coast being some degrees colder than that of the Guinea current to the northward of it.

I need not say that every gallon of water that flows into the North Atlantic from the South Atlantic Ocean must be returned to it in some way, either by a surface or an under-current; and I think I may safely argue that there are no surface-currents sufficient to account for the return of the volume of Antarctic water, and that, therefore, a large portion of the water returned must be from the Arctic basin, and must flow in the manner which I have previously indicated.

The surface-water in these warm regions is lifted by the inflow below it of colder and therefore heavier water from the two polar seas, it then flows off as a surface-current, and the portion of it flowing towards the north pole is deflected by the constant easterly trade winds and obliged to flow westward along the north coast of South America; a large portion of it flowing through the Carribbean Sea into the Gulf of Mexico, and thence through the Gulf of Florida. If we estimate the width of this part of the stream to occupy in the narrows thirty-two miles out of a total breadth of forty-two miles, and its depth at 200 fathoms, its velocity at an average rate of four miles per hour, *i.e.*, in the narrows, it is equal to a stream 2,650 miles wide, 60 feet deep, and running at the rate of one mile per hour, which shows that it is not the mere rivulet it is sometimes described to be. I am aware that its average rate is now said to be less than four miles per hour; but I myself travelled through the Gulf of Florida twice a month for two years, once a month when bound to the northward, keeping in the strength of the stream, and I cannot help thinking that its strength is now very much undervalued, probably in consequence of its rate, as noted, not being strictly confined to the narrows.

This stream is uplifted as it flows out of the northern entrance of the Gulf of Florida by the inflow beneath it of colder and heavier water flowing in the contrary direction from the Arctic Pole; and this, in my opinion, accounts for the arched form of the surface of the Gulf Stream as noted by Maury. Off Hatteras it is only 100 fathoms deep, and being beyond the influence of the trade winds, its easterly momentum, due to its northerly flow, inclines its course to the northward and eastward. When it gets to the northward of 40° of lat., which it does in about 50° of W. long., it appears to spread itself out over the ocean. Now this warm stream has been giving out volumes of vapour during the whole of its northward course, and has from this cause been gradually getting salter and salter; and as it gets shallower, this effect must naturally be greatly increased, besides which the temperature of the stream begins rapidly to decrease. It, in my opinion, then flows onwards towards the pole, gradually losing temperature until it meets with Polar water, which, though colder, has, owing to its admixture with glacial water, a less specific gravity than itself; it then dips below the surface, and, getting colder and colder, runs with great rapidity to the bottom of the Polar basin.

I must now try and prove that this is what takes place, and for this purpose I shall quote from Maury and Capt. Nares.

Maury, vol. ii. pp. 184 and 185.—"Capt. Duncan says, Dec. 18, 1826:—

"It was awful to behold the immense icebergs working away to the north-east from us, and not one drop of water to be seen; they were working themselves right through the middle of the ice.

"Feb. 23, lat. 68° 37′ N. long., about 63° W., about 3 P.M., the iceberg came into contact with our floe, and in less than one minute it broke the ice. Again he says, the berg was drifting at the rate of about four knots, and by its force on the mass of ice was pushing the ship before it, as it appeared, to inevitable destruction.

"Passed Midshipman S. P. Griffin, who commanded the brig *Rescue* in the American searching expedition after Sir John Franklin, informs me (*i.e.*, Maury) that on one occasion the two vessels were endeavouring to warp up to the northward in or near Wellington Channel, against a strong surface-current, which of course was setting to the south; and that whilst so engaged, an iceberg with its top many feet above the water came drifting up from the south, and passed by them like a shot, although they were stemming a surface-current both against the berg and themselves. Such was the force and velocity of the under-current, that it carried the berg to the northward faster than the crew could warp the vessel against a surface- but counter-current."

Capt. Nares, in the Report of the *Challenger*, No. 2, says:—

"All the observations, however, agree in denoting that at a depth of from 80 to 200 fathoms there is a stratum of cold water lying intermediate between the superheated surface-water and the warm underlying layer, which is evidently the continuation towards the cold regions of the main oceanic flow of water."

If Capt. Nares had continued his investigations to the southward of 65° 42′ S., and it had been possible to trace this warm layer as it gradually decreased its temperature, I have no doubt that its course might be traced to the bottom.

I could adduce further confirmation of these views if space would allow me. If my readers will look at a globe, they will readily see that the Arctic Ocean is comparatively a very small sea, and that the effect of large volumes of salt water pouring into the bottom of the Polar basin must elevate the lighter, because fresher, surface-water, and consequently cause a constant outflow towards the equator. A very large stream, known as the Labrador current, runs off as a surface-current through Davis Strait, one fork dipping below the surface, at some seasons of the year, as far to the southward as 42° N., and then underrunning the Gulf Stream; and the other fork, running over the tail of the great bank, and flowing in-shore of the Gulf Stream, runs along the American coast as far south as Florida. The velocity and boundaries of all these streams vary greatly at different seasons, that is to say, the position of the sun affects the ocean as much as it does the atmospheric currents.

A further argument in favour of the cold currents flowing from the surface at the poles is that this is exactly what happens in the circulation of the atmosphere. The north-east and south-east trades, which are generally admitted to be Polar currents, descend on the equatorial side of 30° of lat.; besides in no other way that I can see can you obtain a sufficient motive power. A *primum mobile* depending on the lateral pressure of a column of Polar water as opposed to the lesser weight of a column of temperate or of equatorial water, assuming the length of the ocean (counting say from 70° of lat. to the equator) to be 4,200 miles, and its mean depth to be 3 miles, *i.e.*, a length of 1,400 times its depth, appears to me to be a very insufficient power to move the volumes of water which we know to be constantly circulating between the equator and the poles. (An ordinary sheet of note paper has a length equal only to 928 times its depth.) If, however, it is allowed that the cold streams flow from the surface, and that they do not dip till they reach 70° of lat.[1] (the Labrador current, as before stated, dips much further towards the equator, sometimes in 42° N.), you have still a fall of nearly 3 feet 7 inches per mile of lat. to the equator.[2] I have said sufficient to indicate very briefly my opinions. The arguments I have recently read on this subject appear to be based on the idea that currents flow in one lateral sheet from the pole to the equator. If they did this, there would be no reason why the surface-currents should not flow in a similar way. But they do not; and, if of the depth lately suggested, *i.e.*, 3,000 feet, the Arctic basin could not receive them if they did. The *Challenger* observations seem to me to entirely disprove this view of the subject.

There is a wonderful similarity between oceanic and atmospheric circulation, which I propose more specially to point out at some future time. If we wish to know how the N.E. trades and the S.W. winds pass one another in the upper regions of the atmosphere, let us question the currents of the ocean, and the Labrador current will suggest an intelligible reply. If, on the other hand, we want to know what is the system of ocean circulation, let us ask the currents of the atmosphere; and the Polar currents (*i.e.*, the trade-winds) and the equatorial currents (*i.e.*, the westerly winds of the temperate zones) will strongly suggest to us the answer. It is quite true that there is no salt in the atmosphere, but there is, instead, vapour, which plays as important a

[1] They at most, if not at all, seasons dip in a much lower latitude.
[2] Estimating the depth of the ocean as 2,500.

part in its circulation as salt does in that of the ocean. In conclusion, I would say, look at the isotherms between 65° 42′ S., and 50° 1′ S. published in Report No. 2 of the *Challenger*.

May 10 DIGBY MURRAY

ANCIENT GLACIERS IN AUVERGNE

HAVING just returned from Auvergne, where I have been searching for the tracks of former glaciers among the old volcanoes of the Monts Dome and Mont Dore, I send a few notes to NATURE, in the hope that they may prove useful to other geologists who may explore that most remarkable and interesting country during the ensuing summer. My companions were three members of the Cotteswold Naturalist's Field Club, Sir W. V. Guise (the President), Sir David Wedderburn, and Mr. Lucy, all well versed in the phenomena presented by glaciation.

With regard to the Monts Dome and the country round Clermont Ferrand, it is evident that no glaciers have occupied the vales since the outpouring of the later lava currents, and the volcanic outbursts of the craters of the Puys de Dome; and yet, as I have already mentioned in the pages of NATURE, M. Le Coq discovered remains of the Mammoth, Tichorhine rhinoceros, and Spermophilus, which had been washed into drifts and fissures in the most recent lava currents of Volvic and Gravenoire near Beaumont. Such drifts deserve *especial attention*, as they appear to owe their origin to a period when there was greater transportation of angular and subangular débris by rain-wash and melting snow, or neve, than there is at present. It may have been during this period that the northern animals became inhabitants of Central France. Such angular and sub-angular drifts may be seen in various localities as in the road which descends from the south side of Gergovia, between the village of Merdogne and the high road to Clermont Ferrand, and again at the base of the Puy Dallet, where the high road descends to the village of Dallet, and atmospheric drifts are seen to overlie the old river shingle of an ancient Allier. The geologist who examines the source of the old basaltic current which Mr. Scrope believes to have flowed from the Puy de Berzé, near St. Genest de Champanelle, and to have extended over the freshwater strata of Gergovia, may learn a good lesson as regards the deceitful appearances of glaciation often set up by granitic rocks. Most of the country between Ceyrat, near Mont Rognon, and Theix looks regularly "moutonéed," and may mislead anyone who has not become convinced, by careful examination, that this appearance is owing to atmospheric weathering, and the desquamation of the granitic rocks which separate at the joints and weather into rounded boulders assuming sometimes the aspect of blocs perchés. There are no signs of glaciation, however, among the older basalts which overlie the granite rocks, in so many localities, and which ought to show it if glaciation there had been.

In the country of the Monts Dore the evidence is most puzzling, and in some respects contradictory. Arrived at Monts Dore des Bains we searched carefully for glacier evidences in the valley of the Dordogne and the gorges de l'Enfer and de la Cour, and though some of the knolls are rounded, and there is a vast amount of débris from the rocks around and above, nowhere could we see signs of true moraines, perched blocks, or the usual evidences of glacier action; and certainly the position of the masses of rock called "Les Trois Diables," which I believe are by some set down as blocs perchés, are far too close to the rocks in situ to allow us to attribute their transportation to a glacier rather than to a fall from the precipices above. They belong to the "Chemins du Diable," which are preparing for a similar descent. Again, and I must here state that I arrived at conclusions contrary to those of my friends, I believe that a glacier has descended, in long ago ages, down the valley of the Dordogne, but so long since that the vast masses of débris which have fallen from the rocks which skirt the valley, combined with the wear and tear of atmospheric agencies, the constant shifting of the bed of the Dordogne and its hundreds of tributary rills which during the melting of the snows everywhere wash, roll, wear, and transport the débris of the vale, all have assisted in destroying and masking any glacier evidence there may have been in past times. I was led to this conclusion from the examination of the higher ground, and the detection of what I believe to be moraine matter and transported rock masses, on the road between Mont Dore des Bains and Latour, as on the platform below the Rochers de Beauzac, &c.

The Tranteine valley, where Dr. Hooker discovered the transported rock-masses and which he has already described in NATURE, lies at right angles to the Dordogne valley, runs due south, and faces the Cantal. It is difficult to understand why glacier relics should be preserved in this valley and none in that of the Dordogne. This difficulty, however, vanishes somewhat when surveying the difference in the contour of the ground, the difference in the watershed of streamlets, and the low hill against which the great rock-masses are stranded, consisting of moraine matter overlying beds of basaltic lava. The Tranteine valley may be reached by passing over the Col between the Pic de Sancy and Puy Ferrand, and turning down the gorge to the south, or by the long roundabout route through the village of Latour. We selected the former for our first attack, taking the Latour route two days later. I would here recommend as guide, Guillaume Pierre, of the Hotel Chabourg ainé, to whom I pointed out certain phenomena on descending the gorge, which I think are worthy of notice. I also recommend no one to attempt this route who is not a good walker—"Facilis descensus," &c. The transported rocks, one of which Dr. Hooker sketched, lie stranded in moraine matter, which again rests on beds of black basalt, as may be seen at the little waterfall of the Tranteine stream. The rocks themselves come from the Pic de Sancy, and consist of what Scrope calls "porphyritic trachyte," but perhaps now they may be termed a granitic felstone or a felstone porphyry. Dr. Hooker calls them domite, but this term is now usually applied to the white, light, pulverulent rock like that of the Puy Sarcoui in the Puys de Dome. On the right and left of the transported rocks the hills are rounded, and blocs perchés are seen resting on them. There is a fine section on the Tranteine stream, en route to Picherande, where large transported rock-masses may be seen resting on glacial till. Following the valley down to the bridge which crosses the Tranteine river between Latour and Picherande, the observer will find rounded surfaces and transported moraine matter, but a vast deal of atmospheric weathering has gone on since the days when the ice passed away.

Travelling down the valley of Besse to Lake Pavin, I thought I recognised glacier action; and again at the head of the valley of Chambon; but if glaciers ever flowed down these valleys, it is evident that they must have done so before the eruption of the Puy de Tartaret or the Puy d'Eraignes. The occurrence of the volcanic cone of Tartaret right in the middle of the valley of Chambon is fatal to the supposition that a glacier of any size ever came down from the mountains since the outburst of the cinders and lavas of Tartaret.

If, therefore, after three visits to the volcanic regions of Central France I may be permitted to give a broad view as to the time when glaciers swept down the valleys of Mont Dore, I should say that it was in days of old, when the Alpine glaciers reached the Jura, and the Rhine glacier swept over to the plains of Bavaria, when there were glaciers in the Vosges and in the Black Forest; and that when those ice rivers melted and passed away, so also did the glaciers of Mont Dore. W. S. SYMONDS

Pendock Rectory, Tewkesbury, June 5

NOTES

THE French Government has formally decided to accept the principle of obligatory primary instruction. M. Waddington proposes, moreover, to organise four great Universities in France, viz., at Paris, Lyons, Bordeaux, and Nancy, each of which will have an independent status. M. Waddington's legislation is entirely in accordance with the views which have been so frequently advocated in NATURE. The sooner that similar reforms are universally made, the better it will be for the advance of solid education. The tendency, we are glad to think, to follow the German example, is spreading, and we hope it will soon reach our own country. Such institutions as Owens College, the Yorkshire College, and other similar bodies, cannot too soon spring into Universities with the vigour of youth. The admirable vigour and promptness with which the French Government has carried out the much needed educational reform is in the highest degree hopeful.

ACCORDING to the photographs taken daily at Montmartre by M. Janssen, no spots have been now noticed on the sun since March 25. At the last meeting of the Paris Academy, M. Leverrier announced that in addition to the solar work to be carried on by M. Janssen in the new physical observatory of Paris, M. Cornu has been appointed to make corresponding researches in the National Observatory. It is extremely encouraging to witness astronomical research taken up with such vigour by France as well as by Germany.

WE regret to have to record the loss of one of the most indefatigable of our working naturalists in the death of Mr. Edward Newman, which took place on the 12th inst. at his residence at Peckham at the age of 75. Mr. Newman took up the study of natural history when a young man, as a relaxation from the labours of an active commercial life, and continued ardently devoted to it to the close of his life. He soon established himself as an authority in two branches especially, entomology and pteridology. His "Grammar of Entomology" was published as long ago as 1835; and his "British Ferns" still holds its place, notwithstanding a tendency to excessive species-splitting, as a standard manual of the ferns of these islands. He was the editor of the *Zoologist* and *Entomologist*, as well as of the *Phytologist*, which has ceased to appear for some years; and he was a large contributor to periodical literature, having had the control of the natural history department of the *Field*. Mr. Newman was a Fellow of the Linnean and Zoological Societies, and of several foreign academies, and has been president of the Entomological Society.

THE friends and admirers of the late Daniel Hanbury will be glad to learn that a selection from his papers and essays, with a memoir by Mr. Thomas Ince, F.L.S., is now in the press and will be ready for publication in a few days. The book will consist chiefly of papers on Pharmacology and Botany, and will be illustrated by a portrait engraved on steel and by a number of wood engravings and lithographs. Messrs. Macmillan and Co. are the publishers.

IN addition to the ordinary courses of lectures for science students at South Kensington this year, the Lords of the Committee of Council on Education are making arrangements for a course of sixty lectures on the scientific instruments in the Loan Collection. Their Lordships are in communication with the leading men of science in the country to enable them to carry out the important object they have in view.

ACCORDING to tidings which have been received at Berlin from the German expedition under Dr. Finsch, now exploring Western Siberia, it appears that the expedition left Tyumen on April 13, and proceeded to Omsk. From thence the explorers followed the course of the River Irtish across the steppes as far as Semipalatinsk, where the Russian Governor gave them a very hospitable reception. The travellers made their next halt at a Khirgiz *yourt*. From thence they were at the time of writing about to undertake an expedition into the mountains on the Chinese border. In the second half of the present month the explorers hoped to reach Bernaul, after which it was their intention to follow the course of the river Ob downwards. Dr. Finsch's letters are stated to contain some very instructive and interesting intelligence on animal and vegetable life in the regions traversed. The other expedition undertaken specially to explore the mouth of the river Ob started from Moscow on May 11. The two expeditions are to join at the mouth of the Ob and to return to Germany in company. They are expected back in the course of the autumn.

DR. W. PETERS has lately communicated to the Royal Academy of Sciences of Berlin a description of a very fine new species of wild sheep which is found in Eastern Mongolia, north of Pekin. Dr. O. von Moellendorff, of the Imperial German Legation at Pekin, has forwarded to the Zoological Museum of Berlin an adult male specimen of this animal, which Dr. Peters proposes to call *Ovis jubata*, from the long hairs which adorn its chest.

AT the meeting of the Zoological Society on Tuesday last, Mr. H. E. Dresser, F.Z.S., exhibited a series of specimens of a very fine new species of Snow Partridge, collected by Mr. C. G. Durnford in the Taurus Mountains, and described it under the name of *Tetraogallus tauricus*. This bird, which seems to be restricted to the Taurus range, where it inhabits the higher and more inaccessible mountains, is nearest allied to *Tetraogallus caspius*, but differs in being much larger, in having the upper parts much paler and washed with buff, the hinder portions of the neck and the fore-parts of the back ashy buff, almost unverunculated, a broad pectoral band of ashy buff spotted with black; the flank feathers clear blue grey in the centre, with a chestnut stripe on each side, and an outside margin of black; and the lower breast, instead of being broadly marked with black, is ashy buff, finely verunculated with blackish grey. This makes the fifth species of Snow Partridge now known to inhabit different parts of the Palæarctic region, the others being *T. caspius*, from the Caucasus, *T. himalayensis*, from the Himalayas, *T. altaicus*, from the Altai range, and *T. tibetanus*, from Thibet. Mr. Dresser also exhibited and described, under the name of *Limicola sibirica*, a new species of broad-billed Sand-piper from China, which differs from *L. platyrhyncha* in having the upper parts rich rufous, as in *Tringa minuta*, instead of deep blackish brown, as in the former species.

THERE are now living in the Zoological Society's Gardens, Regent's Park, four specimens of the Giant Tortoises of the Galapagos Archipelago, two having been brought home by the *Challenger*, and deposited by Prof. Wyville Thomson, and two by Commander W. E. de Cookson, of H.M.S. *Peterel*. They were all obtained from Albemarle Island, and are of the species known as *Testudo elephantopus*. These, together with the even larger specimens of *Testudo indica*, from Aldabra, form an unequalled series of living Giant Tortoises.

THE Very Rev. Principal Tulloch, D.D., Vice-Chancellor of the University of St. Andrews, was entertained at dinner on Monday night at St. James's Hall, by a large and influential gathering of the members of the St. Andrews Graduates' Association. Dr. Richardson, F.R.S., Assessor of the General Council in the University Court, presided, and was supported by the Earl of Elgin, Mr. Lyon Playfair, M.P., Dr. Lush, M.P., Sir Joseph Fayrer, K.C.S.I., and a large number of members of the asso-

ciation. The reception given to Principal Tulloch was enthusiastic. The Principal spoke of the past and present of the University with which he is connected. Sir Joseph Fayrer replied for the toast of the University of Edinburgh, and Mr. Danby Seymour eloquently proposed the health of the chairman. It is gratifying to find that this Scottish University is represented by so many eminent men of science in London; we would wish to see the example followed by other Universities.

UNDER the title of "Endowment of Research in America," the *Academy*, at President Gilman's request, gives publicity to the following circular:—"The trustees of the Johns Hopkins University hereby offer to young men from any place ten fellowships, or graduate scholarships to be bestowed for excellence in any of the following subjects:—Philology, literature, history, ethics, and metaphysics, political science, mathematics, engineering, physics, chemistry, natural history. The object of this foundation is to give scholars of promise the opportunity to prosecute further studies, under favourable circumstances, and likewise to open a career for those who propose to follow the pursuit of literature or science. The University expects to be benefited by their presence and influence, and by their occasional services; from among the number it hopes to secure some of its permanent teachers.—*Conditions*:—1. The applications must be made in writing prior to June 1, 1876. The decision of the trustees, will, if possible, be made before July 1. 2. The candidates must give evidence of a liberal education (such as the diploma of a college of good repute); of decided proclivity towards a special line of study (such as an example of some scientific or literary work already performed); and of upright character (such as a testimonial from some instructor). 3. The value of each fellowship will be $500, payable in three sums, viz.: $100, Oct. 1; $200, Jan. 1; $200, June 1. In case of resignation, promotion, or other withdrawal from the fellowship, payments will be made for the time during which the office may have been actually held. 4. Every holder of a fellowship will be expected to render some services to the institution as an examiner, to give all his influence for the promotion of scholarship and good order—and in general to co-operate in upholding the efficiency of the University, as circumstances may suggest. 5. He will be expected to devote his time to the prosecution of special study (not professional), with the approval of the president, and before the close of the year, to give evidence of progress by the preparation of a thesis, the completion of a research, the delivery of a lecture, or by some other method. 6. He may give instruction, with the approval of the president, by lectures or otherwise, to persons connected with the University, but he may not engage in teaching elsewhere. 7. He may be re-appointed at the end of the year. 8. These regulations are prescribed for the first year only." For further information inquiries may be addressed to D. C. Gilman, president of the Johns Hopkins University.

Iron, on the authority of the Icelandic paper *Nordlingr*, states that two enterprising Icelanders, named Jow Thorkellsson and Sigindur Kraksson, have explored the volcanic region of the Dygyur Jelden. They started on their hazardous expedition from the Bardadal on Feb. 7, and in the course of their two days' exploration they succeeded, under great difficulties and dangers, in descending into the crater of the volcano Asya, where, at about 3,000 feet below the upper margin, they reached the bottom, and found themselves on the brink of a lake of seething hot water, which was apparently of great depth. Near the southern extremity of this lake the ground was broken up by fissures and pools, which prevented further progress in that direction, while the entire space resounded with the noise of loud subterranean thunder. North of the great crater the explorers found an opening about 600 feet wide, which appeared to be of about equal depth, from which issued dense masses of sulphurous smoke, accompanied by loud and deafening sounds.

THE Royal Society gave on Wednesday last week a *conversazione*, to which, for the first time, ladies were invited. The experiment was eminently successful.

THE members of the Birmingham Natural History and Microscopical Society propose to visit on Saturday next the Loan Collection of Scientific Apparatus, the South Kensington authorities having promised to afford them every facility. On the same day, under the guidance of Mr. W. R. Hughes, the members of the Society will visit the Crystal Palace Aquarium.

W. B. LOWE has been elected to a Foundation Scholarship at St. John's College, Cambridge, for proficiency in Natural Science. Houghton, Marr, and Slater to Exhibitions.

AN examination will be held at Exeter College, Oxford, in October next, for the purpose of filling up a Natural Science Scholarship tenable for four years during residence, and of the annual value of 80*l*. There is no limit of age for this Scholarship. The examination will be in biology, chemistry, and physics.

THE Society of Geography of Paris, appointed some time since, a special committee on Commercial Geography. We learn from the *Explorateur* that this Committee is starting a new and independent Geographical Society. We have also received a prospectus announcing the formation of a Paris Society of Zoology.

THE Academy of Zurich has granted a doctorship in Medicine for the first time to a young lady, Miss Francisca Tiburtias, aged 23.

M. W. DE FONVIELLE has had a spectroscope constructed with a graduated screen permitting the quantity of light admitted to be diminished in a known ratio. The moving force being regulated at will, the radiometer can be put in a state of rotation under the rays of the most scorching sun and record taken of the motion very easily. With such an apparatus it was shown by comparison with a standard oil-lamp burning forty-two grammes an hour, that on June 9, at 4 o'clock precisely, the radiating force of the sun was equal to fourteen lamps at a distance of twenty-five centimetres from the axis of the radiometer. The apparatus is tried daily at La Villette gas-works, and results of the comparisons will be tabulated and discussed.

PROF. O. C. MARSH has discovered a new sub-order of Pterosauria from the Upper Cretaceous of Western Kansas, North America, differing from the typical Pterodactyles in that no teeth were present in either jaw. The name given to the genus, *Pteranodon*, signifies this. The species was of large size, the skull of *Pteranadon longiceps* being thirty inches from the occipital crest to the end of the pre-maxilla. It must be remembered that the absence of teeth in a Pterodactyle *need* not lead to the inference that it is any way more nearly related to birds than the tooth-possessing species, because the character may have been acquired quite independently.

THE April number of the *Bulletin* of the French Geographical Society contains a memoir of the late Jules Duval, by M. E. Levasseur, an Account of a Journey in Herzegovina, by M. E. De Sainte-Marie, and Notices of the Basques, by Major V. Derrécagaix.

REINWALD AND CO., of Paris, have just added to their "Bibliothèque des Sciences Contemporaines" a work on Anthropology, by Dr. Paul Topinard, with a Preface by Prof. Paul Broca. Williams and Norgate are the English publishers.

In the *Monthly Notices* of the Royal Society of Tasmania for 1874 occur some interesting abstracts of papers read before the Society, including notices of the Angora goat, some species of Tasmanian birds, introduction of the salmon into Tasmanian waters, the Silurian fossils of Tasmania, the Tertiary basin of Launceston, and a list of the plants of Tasmania, prepared in 1875 by Baron Fred. von Mueller. To the notices are appended the meteorological observations made during the year by Mr. F. Abbott at Hobart Town, and by Mr. W. E. Shoobridge at New Norfolk. From the monthly notes we observe that meteorological observations are also made at Port Arthur, Mount Nelson, King's Island, and other places, and sent to the Society, but the results are not published, nor so far as we are aware have they been published since 1866. We hope the Society may soon be in a position not only to publish these results, but also results from a sufficient number of stations, so as to represent adequately the meteorology of the island.

The additions to the Zoological Society's Gardens during the past week include a Cariama (*Cariama cristata*) from South-east Brazil, presented by Capt. W. C. Chapman, H.M.S. *Dido*; two Black-eared Marmosets (*Hapale penicillata*) from Brazil, presented by Mr. G. Newton; a Rose-ringed Parakeet (*Palæornis docilis*) from West Africa, presented by Mrs. Haywood; a Hyacinthine Maccaw (*Ara hyacinthina*) from Brazil, presented by Mr. H. Wilson; a Moor Monkey (*Semnopithecus maurus*) from Java, a Bay Antelope (*Cephalophus dorsalis*) from West Africa, purchased; two Vulturine Guinea Fowl (*Numida vulturina*) from East Africa, a Puma (*Felis concolor*) from Central America, deposited.

SCIENTIFIC SERIALS

Poggendorff's Annalen der Physik und Chemie, No. 3.—According to the kinetic theory of gases, supposing the gaseous molecule to consist of only one atom, the relation of the two specific heats (as Clausius has shown), would be 1·666. The lower number obtained by experiment for several gases may probably be explained by the complex constitution of their molecules. It seemed desirable to MM. Kundt and Warburg to determine experimentally the specific heat of mercury vapour, which has been considered by chemists to consist of monatomic molecules. Their method was to produce a sound in two glass tubes placed end to end, and containing, the one mercury vapour, the other air. Having introduced powder into the tubes, they observed the distances between the nodes of vibration. Applying a formula of acoustics which comprehends, among other things, the densities, the temperatures, and the relation of the specific heats, and taking, as value of this relation in the case of air, the number 1·405, they obtain, for mercury vapour, the number 1·67, which may be considered as fully in accord with the number 1·666 furnished by theory.—In an interesting paper which follows, M. Colley, of Moscow, examines a particular case of work done by the galvanic current. Suppose a current to pass through a vertical column of some salt, *e.g.* nitrate of silver; both electrodes being in this case of silver. In a given time a certain quantity of silver is liberated and deposited. Now, if the current pass up the column, it lifts this silver against the force of gravity, and so does mechanical work, which, in the opposite case (of the current passing down) is not done. It appeared, then, as theory anticipated, that the downward current in such a column (as measured by the galvanometer), was stronger than the upward, and the difference was not greater than theory indicated. But both with a battery current and with that from a Clarke magneto-electric machine, it was considerably less. The author, seeking an explanation, regards as untenable the general views regarding passage of currents through liquid conductors, the phenomena of passage from the solid to the liquid conductor being generally ignored; and he thinks the facts favour Helmholtz's view, which regards the liquid, with the electrodes immersed in it, as a condenser of very great capacity. Weak currents which cannot pass through the liquid yet produce a polarisation of the electrodes (charge of the condenser). With strong currents the only difference is that as soon as the difference of tension has reached a certain limit (maximum of the electromotive force of polarisation), all newly arriving quantities of electricity can unite through the liquid. M. Colley shows how his results are deducible from the state of things thus supposed.—A number of experiments on electric clocks (with Tiede's pendulum) are described by Dr. Joseph Brunn.—Of the few remaining original papers we note one by M. Chwolson on the theory of interference-phenomena.—A good experiment for illustrating the explosive character of a mixture of oxygen and hydrogen gases is described by M. Rosenfeld.

Archives des Sciences Physiques et Naturelles, Jan. 15.—In the opening paper of this number M. de Candolle inquires into the causes of unequal distribution of rare plants on the Alpine chain (See NATURE, vol. xiii. p. 516).—M. Favre follows with a note on the glacial and post-glacial strata of the southern slope of the Alps, in the canton of Tessin and in Lombardy.—M. Pictet discusses the application of the mechanical theory of heat to the study of volatile liquids, and finds some simple relations between the latent heats, atomic weights, and tension of vapours.—A series of meteorological observations from the coast of Labrador, by Moravian missionaries, is communicated by M. Gautier (See NATURE, vol. xiii., p. 60).

SOCIETIES AND ACADEMIES

London

Royal Society, May 18.—"On the Organisation of the Fossil Plants of the Coal-measures.—Part VIII. Ferns continued, and Gymnospermous Stems and Seeds." By Prof. W. C. Williamson, F.R.S., Professor of Natural History, Owens College, Manchester.

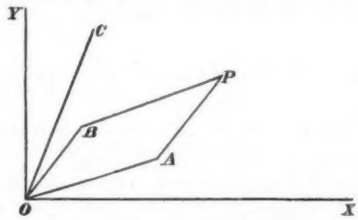
The author described the stem of a new fern, in which the principal vascular axis formed a cylinder enclosing a medulla, as in some Lepidodendra. This vascular cylinder gives off secondary bundles, to petioles, and rootlets, and each vessel is filled with tylose. Two kinds of Fern-sporangia were described—one Polypodiaceous, with a straight, vertical annulus; the other, with the annulus horizontal and subterminal, exhibits a type seen in the recent Schizeaceæ and Gleicheniaceæ. But the chief subjects of the memoir are the stems and seeds of Gymnosperms. Of the former various modifications of the *Sternbergian Dadoxylons* are described, and shown to correspond very nearly to many recent conifers, though with distinctive features of their own, especially in the structure of their woody fibres, and in the leaf-bundles of some species being given off in pairs. The author still excludes the Sigillariæ from the Gymnospermous group.

The most important novelties are the Gymnospermous seeds, exhibiting their internal organisation, found in France by M. Grand-Eury, and by the author in this country. Of these he describes a number of new genera and species in addition to the Trigonocarpons previously described by Mr. Binney and Dr. Hooker. The most remarkable of these is one designated *Lagenostoma ovoides*, in which a large flask-shaped cavity, inclosed within a crenulated canopy, occupies the apical end of the seed, between the apex of the endosperm and the exostome. Brongniart believed, with reason, that such cavities have originated in the absorption of the apex of the nucleus, leaving the corresponding part of the nucular membrane to form the cavity or "lagenostome." In this lagenostome large pollen-grains are found in many cases. Brongniart designates it the "Cavité pollinique." Examples of several other seeds presenting generic and specific modifications of the same type, as well as several species of the well-known genus Cardiocarpum and of Trigonocarpum. In all these the primary nucleus seems to have been absorbed, being now only represented by the investing nucular membrane. Within this is an inner structureless bag, which, in some of the Cardiocarpa, is filled with parenchyma, and which appears to represent the *secondary* perispermic membrane, or what is really the endospermic membrane, or *primary* embryosac of the Gymnosperms. The intimate structure of Trigonocarpum agrees with Dr. Hooker's description of it so far as the longitudinal sections are concerned, save that here, also, a "cavité pollinique" exists. Transverse sections show that the well-known sandstone casts of Trigonocarpum do not represent the external form of these fruits, but are *casts of the interior* of the hard endotesta. This latter was not trigonous externally, like the common specimens, but had twelve longitudinal ridges, three of which, corresponding with those of the sandstone casts, were more prominent than the rest. The endotesta was invested by a delicate parenchymatous sarcotesta. All these seeds appear to have Cycadean

rather than Coniferous affinities. One winged seed alone (Polypterospermum), from the uppermost coal-measures at Ardwick, resembles a true conifer. In conclusion, the author calls attention to the number of yet unknown stems and leaves of Phanerogams, which must have belonged to the numerous seeds now known to exist in the coal-measures of England, France, and North America.

Mathematical Society, June 8.—Prof. H. J. Smith, F.R.S., president, in the chair.—Mr. A. B. Kempe spoke on a general method of describing plane curves of the *n*th degree by link-work. He first described what he calls the *reversor* and the *multiplicator*. (These were first described by him in the "Messenger of Mathematics," vol. iv. pp. 122–3, in a paper "On some New Linkages.") He then explained the *additor* and the *translator*. Let $\phi(x, y) = o$ be the equation to any plane curve of the *n*th degree, and let P be any point on the curve; construct the link-work parallelogram $O A P B$ in which

$$OA = BP = a, \ OB = AP = b,$$



and let the angle $A o X = \theta$, and the angle $B o X = \phi$, then—

$$x = a \cos \theta + b \cos \phi$$
$$y = a \cos\left(\theta - \frac{\pi}{2}\right) + b \cos\left(\phi - \frac{\pi}{2}\right)$$

Substitute these values of x and y in $\phi(x, y)$, expand and convert powers of cosines into cosines of multiple angles, and then the products of cosines into the cosines of the sums and differences of angles, we shall then get—

$$\phi(x, y) = \Sigma[A \cos(r\phi \pm S\theta \pm \alpha)] + C,$$

where r, s are positive integers, and $\alpha = \frac{\pi}{2}$ or o and A and C are constants. The author then proceeded to show how the constructions could be effected by his link-work, and he pointed out that his method would not be practically useful on account of the complexity of the link-work employed, a necessary consequence of the perfect generality of the demonstration. The method has, however, an interest as showing that there *is* a way of drawing any given case; and the variety of methods of expressing particular functions that have already been discovered renders it in the highest degree probable that in every case a simple method can be found. There is still, therefore, a wide field open to the artist to discover the simplest link-works that will describe particular curves. Mr. Kempe further pointed out that the extension of the demonstration to curves of double curvature and surfaces clearly involves no difficulty.—Mr. S Roberts then gave an account of a further note on the motion of a plane under certain conditions. (The former paper was read June 8, 1871).—Mr. J. J. Walker communicated a method of reducing the equation of a nodal plane cubic curve to its canonical form, in which the lines of reference are the nodal tangents and axis of inflexion.—Prof. Cayley described a surface connected with the sinusoid. Its edge of regression was given by the equations $x = r \cos \phi$, $y = r \sin \phi$, and $z = r \cos 2\phi$.—The president made a few remarks in connection with a recent note by M. Hermite, on a theorem of Eisenstein's.

Zoological Society, June 6.—Dr. A. Günther, F.R.S., vice-president, in the chair.—The Secretary exhibited some specimens of a Land-crab, from Ascension Island (*Geocarcinus lagostoma*), which had been presented to the Society by Dr. J. B. Drew, and read a note by Dr. Drew on their habits.—Mr. Sclater exhibited skins of a male and female of the new Pheasant from Borneo lately described by Mr. Sharpe as *Lobiophasis bulweri*. These birds had been obtained alive for the Zoological Society of Amsterdam, but the female only had lived to reach Amsterdam.—A letter was read from Mr. J. H. Gurney, containing some notes on the breeding of a pair of the Polish Swan (*Cygnus immutabilis* of Yarrell), and a description of the young birds.—A communication was read from Dr. Julius von Haast, F.R.S., containing some notes on the skeleton of *Ziphius Novæ Zealandiæ*.—A second communication from Dr. Julius von Haast, F.R.S., contained some notes on *Mesoplodon floweri*.—A communication was read from Dr. G. E. Dobson, containing a description of certain peculiarities in the structure of *Mystacina tuberculata*, which induced him to believe that this Bat used its feet for purposes of locomotion on branches and leaves of trees.—Mr. A. H. Garrod read the first part of a memoir on certain anatomical characters which bear upon the major divisions of the Passerine Birds.—A communication was read from Mr. E. L. Layard, C.M.G., containing notes on the Birds of the Navigators and Friendly Islands, with some additions to the ornithology of Fiji.—Mr. H. Adams and Mr. G. French-Angas communicated descriptions of five new species of Land Shells from Madagascar, New Guinea, Central Australia, and the Solomon Islands.

Royal Microscopical Society, June 7.—Mr. H. J. Slack in the chair.—A number of presents to the society were announced, including some rich diatomaceous earth from Santa Monica, near Los Angelos, sent by Mr. Hanks, of San Francisco.—A paper on a photograph of Nobert's bands, by Count Castracane, was read to the meeting and was supplemented by a short communication upon the same by Mr. H. C. Sorby.—Mr. Henry Davis gave an interesting account of some new observations which he had made upon *Chonochilus volvox*, and illustrated his remarks by drawings showing the principal features of the genus as distinguished from the Melicertians.—Mr. Chas. Stewart described and exhibited under microscopes in the room some minute spines found only round the pentagonal opening on the under side of the shell of the Echinoderms; he also gave a description of the remarkable structure of the large lachrymal gland of the common turtle, and exhibited preparations.

Victoria Institute, May 29.—Annual Meeting.—The Right Hon. the Earl of Shaftesbury, K.G., in the chair. The address was delivered by the Rev. Prof. Birks, of Cambridge. 115 members and associates have joined during the year, and the total number has risen to 690, two-thirds of whom are country and foreign members. The president, on behalf of the Institute, presented a testimonial to Capt. F. Petrie, who had acted as honorary secretary and editor of the "Transactions" for the last five years and a half.

Berlin

German Chemical Society, May 22.—C. Scheibler, vice-president, in the chair.—A. Fischer described a modified water air-pump, remarkable for its cheapness. The brass instrument is sold by Messrs. Dreyer and Rosenkranz in Hanover for ten shillings, or with a manometer fixed to it for twenty shillings. It can be fixed to any laboratory table.—A. Horstmann confirmed observations by F. Isambert respecting the dissociation of the combination of ammonia with chloride of silver. For every degree of temperature a certain pressure can be observed, at which the separated bodies do not re-combine and the combination ceases to be decomposed. He also observed the existence of two compounds of the formulæ $AgCl . 3NH_3$ and $2AgCl . 3NH_3$.—A. Steiner has obtained the following combination of sulphuretted hydrogen with fulminic acid by passing H_2S into fulminate of mercury—

$$C_2H_2N_2O_2 + H_2S = C(NO_2)H_2 - CS . NH_2,$$

microscopical crystals, yielding, with a surplus of sulphuretted hydrogen, oxalic acid, sulphocyanide of ammonium, and sulphur—

$$2(C_2H_4N_2O_2S) + H_2S = 2CN_2H_4S + C_2H_2O_4 + S.$$

The same chemist by treating fulminurate of ammonium with sulphuric acid has obtained nitro-acetonitrile, $CH_2NO_2 . CN$ (hitherto unknown), beautiful colourless crystals, fusing at 40°, burning with a brilliant flame. The substance is not identical with fulminic acid, because with mercury and silver it forms monobasic and not dibasic salts. He also described two bodies formed by the reaction of ammonia on fulminate of mercury, of the formulæ $C_6H_{11}N_9O_3$ and $C_7H_{13}N_{11}O_3$, guanidines, containing fulmi-guanurates. At the end, double salts of fulminate of mercury with sulphocyanide of potassium and ammonium, and also with cyanide of potassium were described.—E. Demole published researches on a body lately described by Baumstark, C_4H_8IO, under the name of ethylidene-iodo-oxethyl. Mr. Demole's researches lead him to suppose that this body is derived from ethylene and not from ethylidene.—A.

Laubenheimer has found nitro-meta-chloro-nitrobenzol to exist in four modifications, chemically identical but differing in physical and crystallographical respects. The same chemist has transformed the above-named substance by boiling it with an alcoholic solution of potash into nitro-chloro-phenol and mono-chloro-chinone, $C_6H_3ClO_2$; and by treating it with aniline into chloro-nitro-diphenylamine, $C_6H_3Cl(NO_2) . NH . C_6H_5$. Nascent hydrogen transforms dinitrochlorobenzol into chlorinated phenylen-diamine.—L. Mears has studied the action of nitric acid on benzanilide, which yields three isomeric nitro-benzanilides.—W. Grethen has transformed acetanilide into ortho- and para-nitro-acetanilides, formed simultaneously.—C. Sennewald described meta-amido-benzanilide. The same chemist has transformed anhydro-benzoyl-diamidobenzol—

$$C_6H_4 . N . C . C_6H_5 . NH,$$

into the amylic substitution-compound—

$$C_6H_4 . N . C . C_6H_5 . N . C_5H_{11},$$

and into the corresponding ethyl-compound.—H. Hübner and F. Frerichs have studied the action of iodide of cyanogen on diamidobenzoles. The result is expressed by the equation—

$$2C_6H_4(NH_2)_2 + CNI = C_{13}H_{12}N_4 = C_6H_4(NH_2)N - C - N(NH_2)C_6H_4.$$

—O. Hesse reported on the properties of a new alkaloid called cusconin.—Th. Cöllen described the action of sulphuric anhydride on para-chlorobenzoic acid, resulting in the formation of a mono-sulphonic acid, $C_6H_4Cl(COOH)(SO_3H)$.—C. Liebermann has observed the formation of rosolic acid when phenol is treated with chloroform and sulphuric acid. This explains the ordinary formation of rosolic acid by heating phenol with oxalic acid.

Stockholm

Academy of Sciences, April 12.—Dr. G. Lindström of Wisby was chosen Intendent of the Palæontological department of the Riks Museum. The following papers were communicated:—On the amplitude of the daily variation of temperature in Sweden, by Herr Rubenson.—On the varieties of Diabase and Gabbro in Sweden, by Herr A. E. Törnebohm.—Recherches sur un nouveau genre des Holothuries, by Docent Hj. Theel.—Contributions to a monograph of the Amphipoda, I.—The family Oxycephalidæ Spence Bate, by Docent C. Bovallius (this paper is written in English).—The land and fresh-water mollusca of Siberia, I., by Dr. Westerlund.—On the Dannemora iron-ore field, by Engineer A. E. Fahlcrantz.—Notes on the vertebrate fauna of North Bohus län, by Herr C. Cederström.—Primæ linæ muscorum cognoscendorum, qui ad Caldas Brasiliæ sunt collecti, by J. Angström, M.D.—Herr Santesson was chosen president for the year now commenced. The retiring president, Herr Wœrn, gave an address on the manufacture of iron and steel in North America.

Paris

Academy of Sciences, June 5.—Vice-Admiral Paris in the chair.—The following papers were read:—Astronomical researches (continued) by M. Le Verrier. He presented vol. xii. of the *Annales de l'Observatoire*, containing the tables of Jupiter and Saturn.—On the thermal formation of ozone, by M. Berthelot. He passed a current of oxygen through a tube, where it was acted on by the silent electric discharge, into a phial containing dilute arsenious acid. The transformation of the acid into arsenic acid was noted, and the heat liberated compared with that liberated in oxidation of arsenious acid by free oxygen. The heat liberated by change of ozone into ordinary oxygen is thus found to be + 14·8 cal., that is, − 14·8 in formation of ozone (or − 29·6 per atom). Ozone is thus a body formed with absorption of heat.—On the absorption of free nitrogen by organic matters at the ordinary temperature, by M. Berthelot. This occurs under influence of the silent discharge, and is well marked in the case of benzine; marsh-gas, acetylene, &c., also show it. Such phenomena must occur in thunder-storms, and have important physiological effects.—On the origin of organised ferments, by M. Pasteur. He controverts M. Frémy's results.—Influence of age of a tree on the average time of opening of its buds, by M. De Candolle. In certain species (horse-chestnut, *e.g.*) age has no influence; whereas, in others (such as the vine), it acts sometimes by retarding, sometimes by accelerating, the epoch in question.—On the displacement of lines in the spectra of stars, produced by their motion in space, by Mr. Huggins.—Examination of the possible mechanical action of light; study of Mr. Crookes's radioscope, by M. Ledieu (continued). He describes the experiments made by M. Fizeau, at his suggestion, with polarised light (the results were negative), proposes new experiments, and applies his theory in explanation of some celestial phenomena.—On the formation of an international committee for scientific exploration of the American isthmus with a view to making a canal, by M. de Lesseps.—M. Cosson presented a small apparatus called a central inflammatory obturator (for cartridges.)—Report on several memoirs of M. Allard on transparence of flames and of the atmosphere, and the visibility of lighthouses with flashing lights.—On the relations between the theory of numbers and the integral calculus, by M. Lucas.—On the photographic images obtained at the focus of astronomical telescopes, by M. Angot.—On the law of Dulong and Petit, by M. Terreil. He interprets it purely with reference to the laws of chemistry. The specific heat of bodies doubles when they cease to be gaseous.—On the irrigations in the south of France, and particularly in the department of the Bouches-du-Rhône, by M. Barral.—On the duration of tactile sensation, by M. Lalanne. Suppose a flexible body which will not hurt the skin by motion in contact with it, to be rapidly moved round the arm or leg. Analogously to the impression of a luminous circle before the eye when an incandescent stick is whirled rapidly, a continuous sensation should at a certain speed be produced, like that from pressure of a bracelet or ring. This is never experienced with less than ten turns per second. The least duration of tactile sensation observed was $\frac{1}{24}$ to $\frac{1}{25}$ of a second. It varies with individuals, and in different parts of the body.—On the galls of leaves of French vines, &c., by M. Boiteau.—Notes on history of Phylloxera, especially the species *Phylloxera Acanthokermes*, Kollar, by M. Lichtenstein.—Memoir on the perturbing influence of neighbouring masses, on the form and disposition of crystals, by M. Brame.—On linear equations of the second order, by M. Pepin.—On the development in series of the functions Al(x), by M. Foubert.—On the number of points of contact of algebraic or transcendent curves of a system with an algebraic curve, by M. Fouret.—Improvement in Watts's indicator, by M. Mallet.—On the inconveniences arising from use of a cable of copper wire as conductor of a lightning-rod, by M. Francisque Michel. Such wires under electric action show, ere long, a series of fractures, which lessen considerably the conducting section.—On the influence of certain salts and of lime on saccharimetric observations, by M. Müntz.—On a derivative of acetylacetic ether, oxypyrotartaric acid, by M. Demarçay.—Combustion of organic matters under the double influence of heat and of a current of oxygen, by M. Loiseau.—Metallisation of organic substances, fitting them to receive galvanic deposits, by M. Cazeneuve.—Action of digitalis compared with that of biliary salts on the pulse, arterial tension, respiration, and temperature, by MM. Feltz and Ritter.—On the vascular apparatus of Trematoda, by M. Villot.

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